Electrochemical and Metallurgical Industry

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The Chemical Engineer.

In his recent address at the inaugural meeting of the American Institute of Chemical Engineers, Dr. C. F. McKenna referred to the words of President Roosevelt in appointing the Commission for the Conservation of our National Resources. Its object is to conserve the foundations of our prosperity; to use our resources, but to so use them as to conserve them; not to limit the wise and proper development and application of these resources, but to prevent destruction and reduce waste. Dr. McKenna remarked that these words "are almost a good definition of chemical engineering." There is more truth in this claim than is generally understood. The point is that the chemical engineer should not be confounded with the industrial chemist. The latter's work is restricted to the chemical industries, the former's field of activity is much wider. Chemistry is at the bottom of our whole civilization and the chemical engineer should be called in far more often than heretofore in important undertakings. We hope the foundation of the American Institute of Chemical Engineers will have this result. But we know various instances where dire necessity works at present to the same end. Our manufacturers are now paying the engineering penalties of the past boom times. They are realizing the errors which were made when working under maximum pressure. But with true American spirit and energy they are overhauling their works, their methods of operation and their engineering staff. It is a characteristic sign of the times that in this period the chemical engineer is called in to contribute his share of knowledge and experience towards the end we all desire, the return of full-blast activity.

Hard Spots in Steel Castings and Diffusion in Fuse Solutions.

This issue contains the conclusion of the article by Mr. Arthur P. Scott, chief chemist of the Dominion Iron & Steel Company, on the causes underlying the formation of a certain hard spot in a steel casting, with an application of the results of this experimental research to the general theory of diffusion in fused solutions. Our readers will certainly concur with us in the opinion that this is one of the prettiest and most interesting researches which have ever been published from the laboratory of a steel company. The investigation started with an analysis—macroscopic, microscopic and chemical—of the particular hard spot and its surroundings, and careful observation coupled with sound judgment led the author systematically to the synthesis of this particular kind of hard spots and the establishment of the physicochemical conditions under which they will occur. The practical steel man is, of course, primarily interested in the underlying cause—that a lump of ferromanganese failed of perfect admixture in the ladle—and it will be a matter of satisfaction to him that this can be generally

avoided by that degree of ordinary care which is always required in steel making. However, the chief interest of Mr. Scott's research lies in the establishment of the troubles which result from the diffusion phenomena occurring between a molten globule of ferromanganese and the surrounding steel. Since what happens is essentially a diffusion phenomenon, it is clear that the temperature will play an important rôle, and it is interesting to note the gradual variation of the phenomena with thermit steel, soft steel, rail steel, according to temperature.

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A comparison between these phenomena in molten steel with the familiar phenomenon of a solution in water suggests itself immediately. Everybody knows the phenomenon of sugar dissolving in water, but it was not until Van't Hoff made his famous generalization on the parallelism between the laws for the pressure in gases and the osmotic pressure in solutions that laws for the latter were formulated. But Van't Hoff's theory only states the conditions which will be reached when equilibrium is established after complete solution. The mechanism of the solution while going on, is still unknown. It is the remarkable feature of Mr. Scott's experiments that he catches the diffusion phenomenon at several stages in its actual progress; the system while in diffusion being suddenly frozen so as to make it available to metallographic and chemical analysis. One result common to all his experiments stands out strongly. Whether diffusion between ferromanganese and steel or between pig iron and steel were studied, there remains always a sharp dividing line between the two during progress of diffusion; each portion of the two essentially maintains its individuality until diffusion is completed. This fact does not fit well with our familiar conception of solution of sugar in water, though we know little about the facts in the latter case. But it fits exceedingly well, as shown by Mr. Scott, with the well-known phenomena of diffusion between pure water and a sugar solution, when separated by a semipermeable diaphragm. This parallelism goes further. The bounding surface between the steel and the ferromanganese acts really like a semipermeable diaphragm, permeable for iron, but not for manganese, etc. This fact is so interesting that it should attract the attention of scientific investigators. In the study of fused solutions, experimental methods of research are available which we cannot employ in aqueous solutions. (To avoid a misunderstanding, we may modify here in parentheses our former remark that a sharp dividing line between the two systems in course of diffusion is an unfamiliar conception with aqueous solutions. As a matter of fact, for the diffusion of water and an electrolytic salt solution, Nernst's osmotic theory leads immediately to the same result, since it postulates that on account of the difference of mobility of the different ions an electric double layer (Helmholtz' doppelschicht) will be established. But Nernst's theory evidently does not apply to Mr. Scott's solid solutions.)

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One particular point in Mr. Scott's paper deserves further attention and investigation. He makes it plausible and probable that a part of the gases that are commonly in solution or combination in molten steel, does migrate with the iron into the manganiferous body. The latter has a lower solvent power for the gases, and when they arrive they are thrown out of solution. The manganiferous iron body increases in size. We have now a double tendency for further expansion; first the affinity which drives the iron from the outside into the manganiferous body, and second the pressure of the gases inside. The phenomenon becomes now quite complicated, but all experimental results of Mr. Scott are thereby easily explained. While this research has led to a complete answer of all questions as to the particular hard spot under test, we trust it will open up a new era of research on fused solutions.

Iron and Steel Statistics.

The Annual Statistical Report of the American Iron and Steel Association for 1907, which has just made its appearance, contains the usual fund of accurate and complete statistics, clearly presented, of the iron and steel industry of the United States. Some of the statistical information contained was given to the public early in the year, while some is entirely new. The production of pig iron has been doubling at an average rate of once in nine years, over a period of several decades, which means an average increase of about 8 per cent. each year. The increase has not been uniform. The alternate doublings require a longer period. Of late the rate of increase has been much more than 8 per cent. a year. Ten months of the year 1907 belonged to a period of rapid increase, and October showed the greatest month's production of all, while in November and December there was a rapid decrease. This made it that the year, which progressed so favorably, ended with but a slight gain in pig iron output over 1906, the increase being only from 25,307,191 gross tons to 25,781,361 gross tons.

* * *

So suddenly had the industry to slow down, towards the close of last year, that the retardation was not equal in all branches. While the production of pig iron showed an increase of 475,000 tons, the production of steel ingots and castings showed a decrease of 35,000 tons, to 23,362,594 tons. On the other hand, the total production of all rolled steel products showed an increase of 263,000 tons, to 17,664,736 tons. It may be noticed that there is a wide discrepancy between the production of steel, as reported, and the production of rolled steel. The production of steel ingots (excluding castings) was 22,-559,477 tons, or 4,900,000 tons in excess of the production of rolled steel. The statistics are comparable, since practically none of the steel ingot tonnage was produced for any other purpose than rolling. Rolled billets which are used for forging are included in the statistics of rolled steel. The loss of nearly 5,000,000 tons was made chiefly in scrap, and this scrap, of course, was not wasted, but was used again, going chiefly to the open-hearth furnace. It is somewhat curious that the proportion should be so large, especially when there is complaint that some of the rolled steel produced is not sound, but should have been cropped more liberally. Doubtless there is more liberal cropping in plants where there is open-hearth practice calling for scrap, but this is not always the case. There are detached Bessemer plants, and there are open-hearth plants using processes which leave a portion of the refined steel in the furnace, to perform substantially the same mechanical function as is performed in ordinary practice when cold scrap is melted, to dilute the pig iron charged. One plant so operated customarily sells all its scrap made from low phosphorus steel, being able to obtain a fancy price from the steel casting

concerns, when with the ordinary open-hearth process it might be inclined to use the material in its own furnaces. Evidently there is a large loss in the handling, partial rolling and remelting of this steel which could be reduced by improved practice. Incidentally, the statistics of steel ingot production mean nothing; they are merely the records of the ingot scales, as has been remarked before. The industry cannot take the 19,000,000 tons of Bessemer and basic pig iron and manganese metals which were used and make 800,000 tons of castings and 23,360,000 tons of ingots, afterward getting only 17,665,000 tons of rolled steel from the ingots.

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An interesting feature of the last four statistical reports has been the tonnage of rolled iron. With 1890 the gathering of separate statistics of rolled iron was discontinued, the statistics including rolled iron with rolled steel. In some years the production of rolled iron probably dropped below 1,000,000 tons, having been 2,518,194 tons in 1890. Of late there has been a revival in rolled iron, due to the great increase in the outcome of scrap, which left material for the rolling mill, despite the keen demand of the ordinary basic open-hearth steel practice. For 1904 the production of rolled iron was given at 1,760,084 tons, while in 1907 this increased to 2,200,086 tons. This was a slightly larger tonnage of rolled iron than was made in 1888, but in that year the production of rolled steel was not much greater than that of rolled iron. The method of production, however, is altogether different. The early rolled iron was puddled iron; the present rolled iron is made largely from scrap, and what boiling is done is largely of cast iron, including turnings and other light material. The contest for the scrap outcome between the iron mill and the basic open-hearth furnace is largely one of cost, and as to cost wages cut an important figure in the iron mills. The wage scales were reduced for the year beginning July 1 by an average of about 8 per cent, and this is helping to keep the trade for the iron mill, with the slightly lower prices prevailing for finished product.

Worlds in the Making.

Prof. Arrhenius in his most stimulating book, "Worlds in the Making," elucidates several principles more or less original to him. The first of these in novelty is, in our opinion, the possibility of life-spores or germs being carried to the upper atmosphere by air currents, the results of large meteoric disturbances, and there being electrified by the electromagnetic radiations from the sun with a charge opposite to the earth's charge. Hence, they are slowly repelled further by what the author terms "radiation-pressure" or a continuous process of slight additional electrifications. So they drift into cosmic space, dormant because of the cold, but yet not dead—to find in the course of countless ages, on the theory of probability, some other planet suitable for organic growth. Of course, it is well known that the extreme evolutionists, like Prof. Haeckel, of Jena, had said that: first, no life could have existed at one time on earth when a molten mass (which fact every scientific mind must allow), and that, second, no germ cell could come into the world because of the heat engendered when the cell struck the atmosphere—as Prof. W. K. Clifford put it, "no simple proto-plasmic shape could come down a fire escape." Finally they deduced that life must have originated from the evolution

of the inorganic molecules to complex organic molecules. This while not impossible would appear to us to require countless aeons and not to have been at all probable. Thus far experiment negatives the possibility. Prof. Svante Arrhenius at present studying the infinite of astronomy, geology and cosmical physics, as he at one time studied so well the infinitesimal of molecular physics, exposits lucidly the broad facts•and theories of earthquakes, the formation of solar systems, the modern nebular hypothesis and other things too diverse to mention. But his explanation of the cosmic transmission of germ cells is to us a most pleasing and rational "deus ex machina" in solving not the origin of life in the universe, but the origin of life on this insignificant, tiny world of ours.

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Another novel idea, never before published to our knowledge, though proposed by at least one man privately and independently, is more practical in its bearing on our industrial life. This is the influence of the increase in consumption of coal and the result of it on the percentage of carbon dioxide in the atmosphere. The further consequence of this will be to increase the rate of growth of vegetable life. The present proportion of carbon dioxide in the air is about 1 part in 2500. It can be estimated by extrapolation that at the present rate of growth of the consumption of coal and all other combustibles the total increment of carbon dioxide from this source will result in the doubling of this figure in the course of two or three centuries. Naturally, this is but a rough estimate, though it is substantially correct. The rate of growth of plant life will be consequently greatly increased. For experimental evidence in proof of the increase of this growth with increasing proportion of carbon dioxide is at hand from work done in the botanical laboratory.

* * *

A tree can be regarded as a nature-made photochemical absorption apparatus working on extremely dilute gases. Hence, the multitude of leaves so placed as to give an enormous surface to both light and air. And a doubling of the percentage of gas to be absorbed evidently should more than double the "reaction-velocity" of the absorption. We know, too, that the percentage was in the carboniferous and cretaceous age so great as to cause the surface of the earth to be covered with vegetation, beside which the luxuriance of our present tropical vegetation would resemble the colloquial thirty pieces of our minimum coinage. And the decline of the monstrous fauna of the Paleozoic eras—such as the megatherium—has been caused by the decline of the luxuriant flora on which they fed. This decline, in turn, was caused by the locking up of so much carbon in what are now coal fields and limestone beds.

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Thus, Arrhenius has made the brilliant prediction that in the course of time the growth of timber will be so much faster than it is at present, that, with the aid of hydro-electric installations, the problem of heat and power and metallurgical demands, will be postponed to the distant future, because it is not "ashes to ashes, earth to earth," but carbon to carbon dioxide, carbon dioxide to carbon. Thus a cycle of regeneration is instituted or at least suggested. In consuming our coal we are changing it into a form in which trees can more easily recapture it, to be again serviceable to the human race. This is a comforting and optimistic thought.

The Iron and Steel Market.

July has shown a material and clearly marked improvement in nearly all branches of the steel trade. The buying has been better and production slightly larger, than in June. The showing has been very satisfactory to the steel trade, since July is usually the quietest month of the year, and for it to show an improvement over June is therefore very favorable. At the same time it is recognized that the buying in July has been of an intermittent character and it has been evident that buyers are merely supplying their requirements in a hand-to-mouth fashion. The reductions in prices early in June settled the market for a while, buyers hesitating, so that on account of this unsettlement and the desire to pass over the midsummer inventory period purchases were in considerable degree deferred. This, it is inferred, has tended to make the actual buying present a distorted view of the real demand, and the trade, while feeling very hopeful for the future, is not disposed to conclude hastily that the improvement in buying in July over June necessarily presages a continued movement towards greater and greater activity. It is believed in most quarters that there will be a gradual improvement through the half year, but not a great deal of faith is felt in the movement which has occurred thus far.

The tin plate industry has run at almost full capacity through July, which is quite contrary to precedent, and is due to the lateness of the beginning of the buying movement for the spring trade. Since the middle of February the tin mills have been making more than 90 per cent of the their normal output in the period, if indeed they have not fully equalled it. The wire industry has been operating to 75 per cent, and still maintains about that gait. Sheets and merchant pipe have averaged about 50 per cent, and the improvement in July brings them back to about that rate. The plate, shape, rail and merchant bar mills have been doing materially less than 50 per cent and have shown no great improvement in July over the average of the first half.

A new penalty system has been adopted in the Lake Superior ore trade, on the insistence of furnace interests. Until this change, Lake Superior ores, except special grades such as silicious ores, have sold on the straight unit basis. The standard price is fixed for Bessemer and non-Bessemer, Mesaba and old range, and the ores are sold on a guarantee of 55 per cent iron for Bessemer ores and 51.50 per cent iron for non-Bessemers, both in the natural state. From this basis the unit price is ascertained, and hitherto the premiums and penalties have been on a straight unit basis. This, of course, is not altogether equitable, as prices are f. o. b. Lake Erie docks, and the consumer must pay freight to the furnace on the material which is not iron, having besides to suffer a decrease in output and an increased coke and limestone cost, if the ore runs below the guarantee.

The new system leaves the penalty on a straight unit basis down to 50 per cent iron. Between 49 and 50 per cent the additional penalty is increased by 50 per cent, and below 49 per cent it is increased by 100 per cent. Thus, on Bessemer ores, the guarantee being 55 per cent, five units are deducted if the ore runs 50 per cent. If, for instance, the ore runs 49.50 per cent, three-fourths of a unit additional is deducted, making the total penalty 5¾ units; if the ore runs 49 per cent, 6½ units are deducted; if 48.50 per cent, 7½ units are deducted; if 48 per cent, 8½ units, and so on. The ore interests embraced the opportunity slightly to increase the premiums on ores running above the guarantee. For one additional unit above 55 per cent on Bessemer and 53 per cent on non-Bessemer ores the unit price is increased by one cent; for the next unit two cents, and so on up to five, beyond which the standard unit price prevails.

PIG IRON.

The pig iron markets have been extremely dull, but at the end of the month are beginning to show more signs of life. Sales during July have been the smallest for a long time. Prices have sagged off slightly, possibly 25 cents as an average of all districts and grades. Southern iron is weak at $12, Birmingham, for early delivery, some interests being ready on occasion to shade this price about 25 cents. The large interests which sold large blocks for forward delivery at special prices are inclined to hold the market. In the Pittsburg district Bessemer is still quoted nominally at $16, valley, or $16.90, delivered Pittsburg, but on small lots for quick shipment this price could be shaded a trifle. Early in the month a sale of 10,000 tons of chill cast Bessemer was made at $16, valley, for August, September and October delivery, this being the principal transaction. Basic is 25 cents lower, at $15 to $15.25, valley. The largest transaction was 8000 tons of prompt, bought by a Pittsburg middleman on behalf of the Pittsburg Steel Company, Monessen. The iron netted the furnace $15.25 at furnace, but the freight rate from this furnace to Monessen is 85 cents, against $1.10 from the valleys, so that the sale was made on the basis of $15, f. o. b. valley furnace. Foundry iron is quoted at $14.75 to $15, valley furnace, and forge at $14.

STEEL.

The billet market has been very quiet, not enough business arising to test thoroughly the stability of the regular price of $25, Pittsburg, for 4 x 4 billets, ordinary carbons. Sheet bar shipments have kept up well, and there have been a number of small transactions, at the full price. Most consumers are covered by regular contracts. The market is firm, at $27.50 delivered Pittsburg and nearby points, and $27, f. o. b. Pittsburg for other points.

FINISHED PRODUCTS.

A slight improvement has been noted in railroad buying. No large orders are being placed, but small orders are coming from a larger number of railroads than formerly, and quick shipment is desired in all cases. The work being done by the railroads is nearly altogether in the line of locomotive, car and track repairs, very little new work being under way. Buying of sheets has improved slightly and the improvement gives some promise of permanence. Buying of wire products in July has been better, relative to second quarter business, than is usually the case, and the same is true of merchant pipe. The few mills making line pipe, about 12 in., are quite busy, chiefly on some large contracts placed by the Standard Oil Company, and this has given a good bit of work to some plate mills, Homestead in particular.

The wage scale for union rolling mills was arranged July 11 at Detroit between the Western Bar Iron Association and the Amalgamated Association, the scale being accepted afterwards by the Republic Iron & Steel Company and the independents not represented at Detroit. The reductions average about 8 per cent. The puddling scale provides a rate of $5 a ton when iron bars at $1.20 cents or less; for each twentieth cent above 1.20 cents the puddling rate advances 12½ cents. The old scale started with $5 puddling on one-cent bar iron, advancing 12½ cents for each twentieth cent advance in the bar iron price, so that on the higher number the new puddling rate is 50 cents lower than the old. The bi-monthly settlement showed an average realized price on bar iron shipped during May and June of between 1.35 and 1.40 cents, making the puddling rate $5.37½. The previous rate had been $6.12½, based on a 1.45-cent bar iron price, and the old wage scale.

Official prices, which are strictly held, except for occasional shading in sheets and narrow plates, and regular shading of $3 to $5 a ton in light rails, are as follows, all f. o. b. Pittsburg, except that standard rails are f. o. b. northern mill:

Standard rails, 50 lb. and heavier, $28.

Light rails, 25 to 45 lb., $28.

Plates, 1.60 cents for tank quality.

Shapes, 1.60 cents for beams and channels, 15-in. and under, angles and zees; tees, 1.65 cents; large beams, 1.70 cents.

Steel bars, 1.40 cents, base. Iron bars, 1.40 cents, delivered Pittsburg; 1.35 cents, f. o. b. Pittsburg for western shipment, and 1.50 cents, Chicago.

Sheets, 2.45 cents net, for black and 3.50 cents net, for galvanized, 28 gage.

Tin plates, $3.70 for 100-lb. cokes.

Wire nails, $1.95; plain wire, 1.70 cents.

New Haven Meeting American Chemical Society.

The thirty-eighth general meeting of the American Chemical Society was held in New Haven, Conn., June 29th to July 2d, and was one of the most successful summer meetings ever held by the Society. Two hundred and fifty members were present and one hundred and seventy-four papers were presented.

The large number of papers made it necessary to hold more sectional meetings than usual, and the Society met in six sections for the presentation of papers.

The Society met in the lecture rooms of the Sheffield Scientific School, and the following nine papers were presented in general session before all the members: "Official Inspection of Commodities," by A. L. Winton, chairman of the agricultural and food section. "The Increasing Importance of the Rarer Elements," by P. E. Browning, chairman of the inorganic section. "The Analyst, the Chemist and the Chemical Engineer," by Wm. D. Richardson, chairman of the industrial section. "A Discussion of Some of the Methods Used in Determining the Structure of Organic Compounds," by Wm. McPherson, chairman of the organic section. "Our Present Knowledge of Plant Proteins," by T. B. Osborne, chairman of the Biological and sanitary chemistry section. "Some Applications of Physical Chemistry," by Frank K. Cameron, chairman of the physical chemistry section. "Chemical Publications in America in Relation to Chemical Industry," by W. A. Noyes. "The Electrolytic Theory of the Corrosion of Iron as Applied to the Protection of Steam Boilers," by W. H. Walker. "The Research Chemist," by W. R. Whitney.

On Wednesday afternoon, July 1st, an excursion to Ansonia was enjoyed by the visiting chemists for the purpose of visiting the works of the Ansonia Brass and Copper Company and the Coe Brass Manufacturing Company. On the evening of the same day the members met on the east shore for a social outing and dinner.

The organization of the Division of Industrial Chemists and Chemical Engineers was a feature of the meeting, and the following officers were elected: Chairman, A. D. Little; vice-chairman, A. H. Low; secretary, B. T. B. Hyde; executive committee, Wm. H. Walker, Wm. Brady, J. D. Pennock, W. C. Ebaugh, F. B. Carpenter. Twenty-eight important papers were presented before the Division and marked enthusiasm was shown. A movement is also on foot for organizing the Food Chemists, the General and Physical Chemists and the Fertilizer Chemists.

The rapid growth of the Society under the impetus of the organization of chemists into special groups and the continually improving quality of its journals was noted by all, seven hundred new members having been added in the last eight months.

Matters of decided importance were brought before the council and acted upon. A new section of the society was established with headquarters at Louisville, Ky. It was decided that the winter meeting should be held in Baltimore in affiliation with the American Association for the Advancement of Science, and that the summer meeting for 1909 should be held in San Francisco.

The society having been represented by its president in the recent conference in Washington on the conservation of our natural resources, it was voted that a standing committee on the conservation of our natural resources be established, and that the American Chemical Society should attempt to point out how chemists can assist this movement which, it is believed, will lead to important results.

W. D. Richardson was elected editor-in-chief of the new *Journal of Industrial and Engineering Chemistry*, and thirty-four gentlemen were elected as associate editors to cover the different branches of chemical and metallurgical industries.

The committee on the qualifications of chemists made a preliminary report on the establishment of an institute of chemistry, which has been under consideration for the past two years.

It was decided, however, on account of its great and far-reaching importance, to refer this matter again to a representative committee of fifteen for further consideration to report back to the council.

The committee appointed to consider the training and education of chemists and chemical engineers made its report, and as a result a movement is under way to establish a section or division of chemical education within the society, which shall especially appeal to teachers, and shall study more particularly the existing standards and methods of instruction throughout the country, and the possibility of improving same.

The society adjourned after one of the pleasantest meetings in its history.

CORRESPONDENCE.

Steel Foundry Practice.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—In your June issue, Mr. R. H. Wolff, U. S. Representative for the Héroult electric furnace, publishes a transcript of analyses of steel made by that process, evidently covering an entire month's output, and makes some statements in conjunction therewith, all of which are most interesting to the modern steel-maker.

The record of the La Praz analyses commands attention for its very low average of sulphur and phosphorus, particularly the former. But while it is generally conceded that steel containing what may be called a minimum of these objectionable elements can be produced in the electric furnace, and that great progress has been made by very eminent men in developing that process, I submit that the major portion of Mr. Wolff's remarks on steel founding are of interest chiefly because of their unfairness to a large quota of ingenuous and intelligent men, whose efforts toward improving steel foundry practice have been crowned with very gratifying results, and who are still finding time, in the routine of their regular shop duties, by experimentation and observation, to evolve methods promising better things for the future.

Mr. R. A. Hadfield has said, "There is no rapid or royal road to the production of sound steel castings; this is only attained by long experience combined with specialized knowledge." Every steel founder knows this to be true, but his patience and untiring zeal have brought his adopted industry to a higher degree of excellence during the past five years than he formerly imagined possible. In this he has been wonderfully assisted by the producers of various refining and other alloys, to whom he is glad to render due credit.

Many instances could be cited in proof of improvement in steel foundry practice, in recent years, as for example, the use of aluminium, in quieting the steel, *since* the advent of ferro-manganese and ferro-silicon. One steel foundry of which the writer has knowledge, ten years ago added 8 lb. of aluminium to a 10-ton basic open-hearth heat. Six years ago it was customary in another steel foundry to use 10 lb. of aluminium in a 25,000-lb. basic heat. At the present time, 4 lb. of aluminium (without any of its alloys) is quite sufficient for a 22-ton heat, made on a basic hearth, for castings requiring a homogeneous machined surface.

As to examples of shapes formerly unheard of in steel molding, in the last two years, castings of ⅝ in. sections in all parts,

with over-all dimensions of 13 ft. 10 in. x 9 ft. 9⅝ in. x 1 ft. 4¼ in., weighing but 3750 lb. have been successfully made in basic open-hearth steel, and at present complete underframes for locomotive tenders are being cast by the same process, 22 ft. 5¼ in. long, 10 ft. 2 in. wide, and 2 ft. 1 in. deep, weighing only
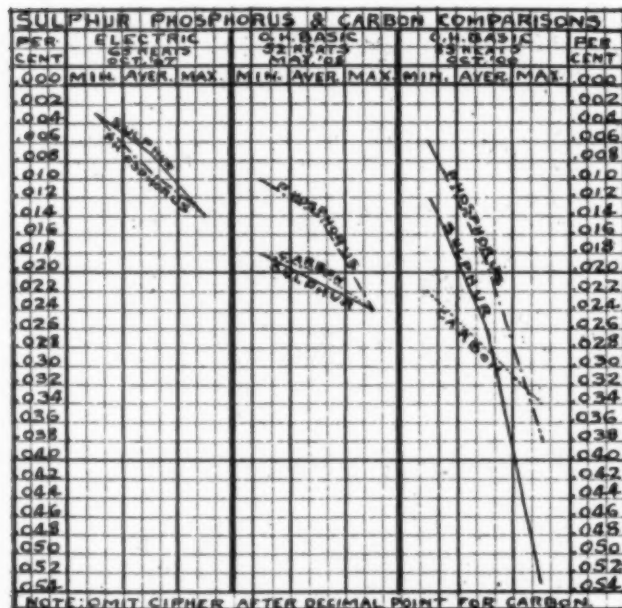

FIG. 1.—SULPHUR, PHOSPHORUS AND CARBON COMPARISONS.

9930 lb. The Tropenas converter has enabled the steel founder to make steel castings of comparatively infinitesimal dimensions and wafer-like sections. I recall a certain lot of 300 of such castings, weighing 14 to the pound, that were successfully turned out. Because of the established fact that the last part of a basic heat is not suitable metal for castings to be subjected to severe strains (the analysis suddenly changing as the slag line nears the nozzle), several foundries are now pouring that portion of the heat in ingots or in pigs on the floor, to be remelted and refined. This speaks for itself, not only of the progressiveness, but the *conscientiousness* of the modern steel casting producer.

So much for Mr. Wolff's statement that "it is a well-known fact that the steel casting industry has made no progress of late years." But Mr. Wolff further states, "I am told, on good authority, that there is a wastage of about 50 per cent in medium and light weight castings, particularly in castings of odd shapes. This is principally due to impurities and sluggishness of the metal in casting." It is difficult to decide whether by "wastage" Mr. Wolff means to include defective castings, sculls, gates, risers, chippings, melting loss, and any extra metal that may be added to sections to assist in running the metal, or whether the first mentioned, commonly called "scrap" castings are meant. In either case, however, the statement is wrong, and it is to be regretted if any practical steel founder has so misguided Mr. Wolff. A well-managed steel foundry, month

in and month out, will run under an average of 4 per cent of "scrap" castings, if it be not necessary to work a night shift of molders and core-makers, and 6½ per cent if operating under the latter handicaps. The yield of good castings will average 68 per cent of the metal charged into the furnaces in basic practice, and 70 per cent with acid bottoms, this difference resulting from the lower melting loss of the latter. As to causes for bad castings, steel founders entirely agree with Mr. E. S. Cramp, who has stated that "one of the most fertile sources of defects in castings" (steel) "is a bad design"—and progressive steel founders, of whom there are many, are learning rapidly how to solve the problems of such designs, when the engineers are prohibited from improving them, from a foundry standpoint.

I trust, while Mr. Wolff's criticisms are fresh in mind, that you will afford space in your journal for the publication of this letter, together with appended chart, showing what was in 1900 regarded as excellent practice in what was then considered the best and most modern type of basic furnace, under the skillful manipulation of a melter of technical and practical ability, and what is now being done. For purposes of thorough comparison, I have also charted the phosphorus and sulphur determinations from the La Praz laboratory record. Note, however, that I have not shown the carbon in the latter, having no knowledge that a uniformity of this element was aimed at in the electric furnace, as *was* in the case of the two open-hearth basic furnaces. I hope you will also reproduce enclosed photograph showing examples of physical qualities of steel made in the daily routine, without the melter's knowledge that the tests were to be made.

The writer by no means poses as being associated with a select organization of steel founders who are responsible for most of the improvement made in recent years, for he knows that many of his colleagues can produce as conclusive evidence as he of the advanced and still advancing stage of the art. Your journal is of such value to metallurgists generally, and is consequently read by so many intelligent engineers, that Mr. Wolff's article is liable to do great harm to an industry that deserves better treatment, unless replied to by one who knows.
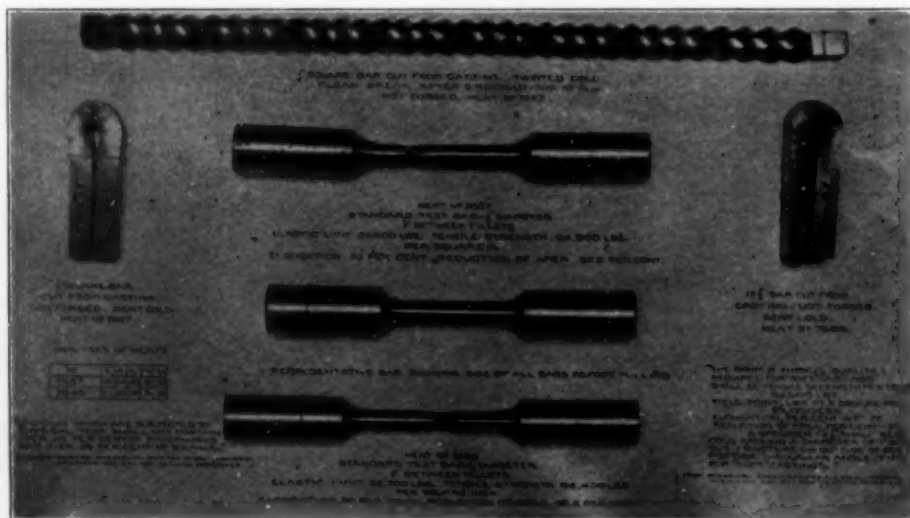

FIG. 2—EXAMPLES OF PHYSICAL QUALITIES OF OPEN-HEARTH STEEL.

This is my apology for writing at this length on this incidental feature of Mr. Wolff's dissertation, which, in so far as it exhibits the refining possibilities of the electric furnace, excites my admiration.

R. A. Bull,
General Superintendent, Commonwealth Steel Company.
Granite City, Ill.

Treatment of Iron and Steel in the Electric Furnace.

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In reading the November issue, 1907 (vol. V, No. 11), of ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, my attention was attracted to the articles on the reduction of iron ore in the electric furnace (page 445) and on the Lash steel process (page 455). Both articles refer to iron reduction in the electric furnace and point out the difficulties which interfere with the practical solution of the problem. But these difficulties were solved by me years ago.

It may be of interest to give here the results which I have regularly obtained for some time, and which prove that the application of the electric furnace to the treatment of iron ores and of iron agglomerates in general has passed the scientific
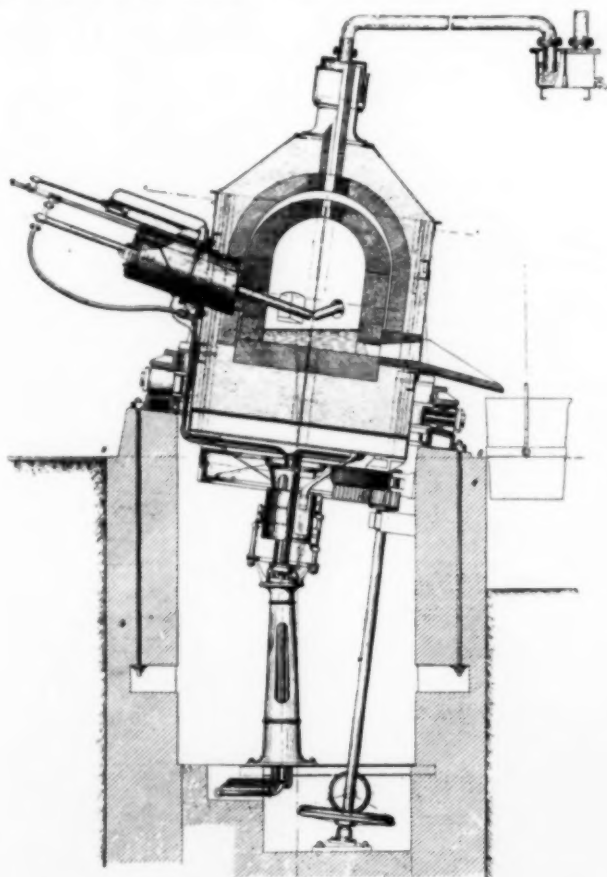

FIG. 1.—VERTICAL SECTION OF ROTARY ELECTRIC FURNACE.

experimental stage and has taken its place in the industrial arts.

After a long theoretical investigation of this problem, which is of utmost importance to countries poor in fuel, I made, in 1898, the first practical trial. This first attempt was satisfactory indeed, since in the first run I succeeded in turning out malleable iron directly from ore in a single operation.

As to the consumption of energy, I was led to entertain the hope that with more adequate apparatus the utmost economy might be obtained and that the inconveniences, which are always found in apparatus built for a first experiment, could be overcome with such ease as to approach almost the theoretical limit of efficiency.

In my memoir presented at the sixth International Congress of Applied Chemistry at Rome, 1906, I summed up the results of my studies made since 1889, and proved:

First, that a maximum consumption of 4 hp-hours is quite sufficient to produce in an electric furnace the same results as

1 kg of coal in a blast furnace, and that with energy produced by water power at a cost of lira 40 ($7.72) per hp-year, or lira 0.005 (about 0.1 cent) per hp-hour, and with fuel costing lira 20 ($3.86) per ton, the electric furnace is on equal terms with the blast furnace.

Second, to make the most of electrically generated heat for
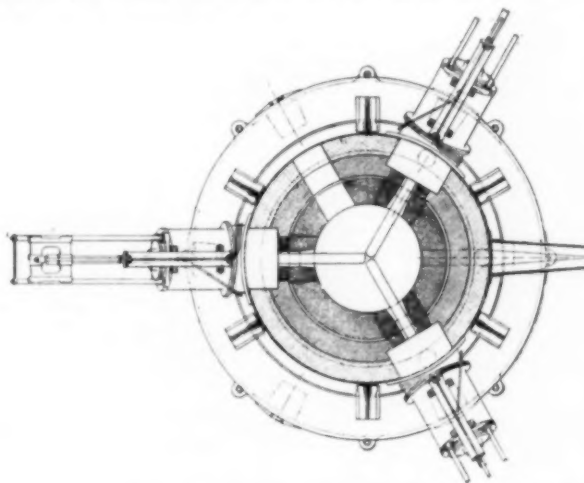
FIG. 2.—HORIZONTAL SECTION OF ROTARY ELECTRIC FURNACE.

industrial and particularly metallurgical purposes, the apparatus should fulfill the following fundamental conditions:

(a) The chamber in which the electrical energy is transformed into heat and in which the metallurgical process takes place should be protected from the atmospheric air, so as to provide an absolute neutral atmosphere.

(b) The heat should be generated from electricity at the highest possible temperature.

(c) The material to be treated ought not to come into contact with other substances which might have a pernicious influence upon the composition.

(d) The whole apparatus, wherein the various operations are executed to obtain a predetermined final product, should be designed and built so as to work continuously at full charge.
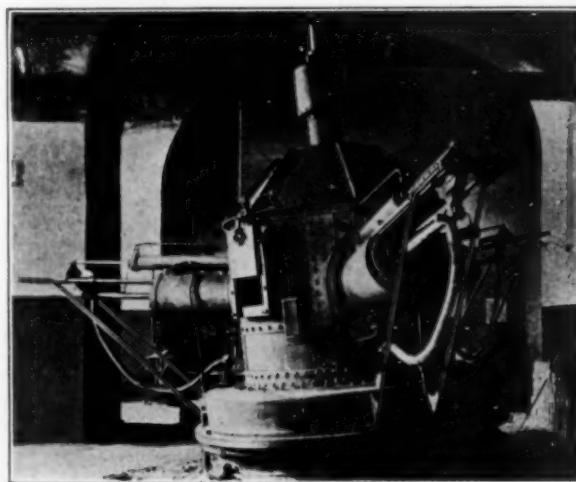
FIG. 3.—200-HP ROTARY ELECTRIC STEEL FURNACE, ARTILLERY WORKS, TURIN.

Without repeating the particulars published in the above paper, I will limit myself here to the description of the furnaces invented by myself in order to make the best use of this new heat producer for metallurgical purposes.

Figs. 1 and 2 show diagramatically my rotary electrical furnace, consisting of an iron-sheet cylinder with conical roof

TABLE A.—DIRECT CONVERSION OF ORE INTO IRON AND STEEL IN A 200-H.P. FURNACE.

| Composition of the charge.	Analysis.		Tests.	
	Charge %	Casting %	Breaking load kgs per sq. mm.	Elongation %
1000. Ore[1]	Fe²O³ 68.700	Fe 99.485	....	..
350. Lime	Mn²O⁴ 3.229	C 0.250	....	..
240. Charcoal	Si O² 17.150	Mn 0.120	....	..
80. Aqueous solution of silicate of soda at 25%..	Al²O³ 2.	Si 0.070	....	..
	Ca O 1.	Ph 0.010	....	..
	Mg O 5.670	S 0.065	....	..
	Ph 0.150	....	....	..
50. Calcium Carbide	S 0.120	....	....	..
Identic charge[2]	do	Fe 99.450	55	23
		C 0.260	....	..
		Mn 0.210	....	..
		Si 0.030	....	..
		Ph 0.010	....	..
		S 0.040	....	..
Identic charge[2]	do	Fe 99.235	....	..
		C 0.300	....	..
		Mn 0.240	....	..
		Si 0.140	....	..
		Ph 0.015	....	..
		S 0.070	....	..
Identic charge with addition of hematite pig-iron for recarburation[4]	do	Fe 98.620	86.3	13
		C 0.800	....	..
		Mn 0.300	....	..
		Si 0.220	....	..
		Ph 0.015	....	..
		S 0.045	....	..

[1] The energy consumption in this run was 4.5 kw.-hours per kg of casting.
[2] Energy consumption 4.3 kw.-hours per kg.
[3] Energy consumption 4 kw.-hours per kg. In these runs the calcium carbide was introduced after removal of the slag.
[4] Energy consumption 4.2 kw.-hours per kg. The hematite pig-iron was added after removal of the slag.

TABLE B.—FERRO-ALLOYS FROM ORE IN 100-H.P. FURNACE.

Composition of charge.	Analysis.	
	Charge %	Castings %
1000. Wolframit[1]	W O² 69.800	Fe 35.200
190. Charcoal	Si O² 2.000	W 58.000
40. Lime	Fe O 20.500	C 2.400
80. Solution of 25% Silicate of Sodium	Mn O 7.300	Mn 3.192
	S 0.200	Si 1.244
	Ca O traces	Ph traces
	Mg O "	S "
	Ph²O⁵ "	
Identic charge.[2]	do	Fe 28.630
		W 65.660
		C 2.062
		Mn 3.500
		Si 1.028
		Ph traces
		S "
Identic charge.[3]	do	Fe 22.715
		W 69.700
		C 2.508
		Mn 3.600
		Si 1.300
		Ph traces
		S ..
1000. Manganese-Ore[4]	Mn²O⁴ 45.650	Fe 17.762
300. Charcoal	Fe²O³ 16.100	Si 17.600
60. Lime	Al²O³ 3.050	Mn 62.000
	Si O² 30.160	......
80. Solution of 25% Silicate of Sodium	Ba O 0.150	C 1.800
	Ca O 1.200	S traces
	Mg O 0.430	
	S 0.817	
	Ph²O⁵ 0.340	Ph 0.028

[1] The energy consumption in this run was 6 kw.-hours per kg produced.
[2] Energy consumption 6.8 kw.-hours per kg.
[3] Energy consumption 7.5 kw.-hours per kg. Theoretically the ferro-tungsten produced in the first three runs should contain 20.6% Fe, 71.5 W, 7.1 Mn, 1. Si.
[4] Energy consumption 7.4 kw.-hours per kg. The intention was to produce a silico-manganese, containing about 60% Mn and 20% Si.

lined on the inside with refractory material. The melting chamber is also cylindrical, with a cupola of the same firebrick. Suitable openings are provided for the electrodes, which project towards the center of the furnace, their ends being at proper distance from each other for the formation of the arcs and at a convenient height above the bottom.

The electrodes are protected on the outside by water-cooled cast-iron cylinders, fitted to the mantle of the furnace. The movement of the electrodes is controlled by guide-rods outside

TABLE C.—REFINING STEEL FOR PROJECTILES IN 200-H.P. FURNACE AT ARTILLERY WORKS, TURIN.

Composition of charge.	Analysis of castings.					Weight of output	Breaking load kg per sq. mm.	Elongation %
	C	Mn	Si	Ph	S			
350. kg Scrap	0.420	1.231	0.180	0.03	0.03	650	67	19
200. Broken Projectiles	0.440	1.498	...	...	...	665	74	17
100. Scrap lathes	0.425	1.440	...	...	...	642	71	20
2.5 Ferro Silicon	0.400	1.386	...	...	...	630	67	19
10.5 Ferro Manganese	0.465	1.224	0.200	0.035	0.04	663	72	17
0.2 Aluminum	0.495	1.404	...	...	...	662	78	15
6. Lime	0.490	1.440	...	...	...	656	78	16
1. Ore	0.430	1.260	0.150	0.025	0.035	656	69	18
	0.525	1.296	...	...	...	650	79	15
	0.460	1.476	...	...	...	640	76	16
	0.515	1.436	...	...	...	670	81	15
	0.505	1.540	...	...	...	656	83	14
	0.450	1.264	0.170	0.031	0.033	650	76	16
	0.415	1.440	...	...	...	650	71	18
	0.445	1.332	...	...	...	652	76	16
	0.400	1.444	...	...	...	652	69	18
	0.405	1.501	0.180	0.030	0.027	655	71	18
	0.465	1.303	...	...	...	650	73	17
						11,749		

The weight of the material charged in 18 runs was 18 × 663 = 11,934 kg and that of the steel obtained 11,749, the loss being about 1½ per cent. The electric energy consumption was 1.25 kw.-hour per kg of steel.

of the furnace. To the end of the carbon electrodes a metallic rod is fitted, the end of which is connected to a flexible cable leading beneath the furnace to the slip-rings for current supply.

Above each of the water-cooled cylinders, which protect the outside of the electrodes, a small hydraulic pressure cylinder is provided, the piston rod of which is connected with the metallic rod of the electrodes and thus controls the movement of the electrodes and regulates the distance between their terminals within the furnace.

The lower part of the furnace, somewhat above the bottom, is surrounded by an L-shaped rail of cast iron running upon conical rolls. Below the rolls there is another cast-iron rail, resting on the inclined top of the pit-wall and thus forming the support of the furnace. The longitudinal axle of the furnace is, therefore, inclined by a certain angle against the vertical.

The furnace is revolved by means of a strong gearing at the bottom. Attached to the head wheel are properly insulated copper rings, which, by means of copper bars and the above-mentioned elastic cables, transmit the current to the electrodes. The current is supplied from the generator to a series of brushes disposed round the top of an iron support in the center of the pit and cables. These brushes and slip-rings maintain a continuous connection between generator and electrodes during the rotation or standstill of the furnace.

Besides the brushes there is a distribution valve mounted on the top of the stationary iron support, which distributes the water for the pressure regulators and the cooling cylinders protecting the electrodes. This, like the electrical contrivance, acts continuously.

The discharge is at the bottom of the melting chamber, while opposite to it another opening is left for charging. In the center of the brick cupola an exit is provided for the volatile products of the furnace reactions. Through this exit the gases escape into a metal tube shut by a sand valve and leading to a vessel filled with water, from which the gases may escape into the open air or be used otherwise. This arrangement prevents any entering of air from the atmosphere into the melting chamber; neither could air get in on opening the charge hole or discharge hole since the pressure inside is higher than outside, on account of the higher tension of the gases at the elevated temperature inside.

It is obvious that this furnace does fulfill the conditions laid down before:

(a) From the chemical standpoint, the atmosphere throughout the melting chamber is neutral.

(b) The electric energy is transformed into heat by the voltaic arc at the highest temperature obtainable.

(c) The material treated is not in contact with the electrodes or other materials and hence its composition is not subjected to any alteration.

(d) The rotation of the furnace maintains the molten material in an active motion, facilitates the chemical reactions, already well prepared by the elevated temperature, shortens the
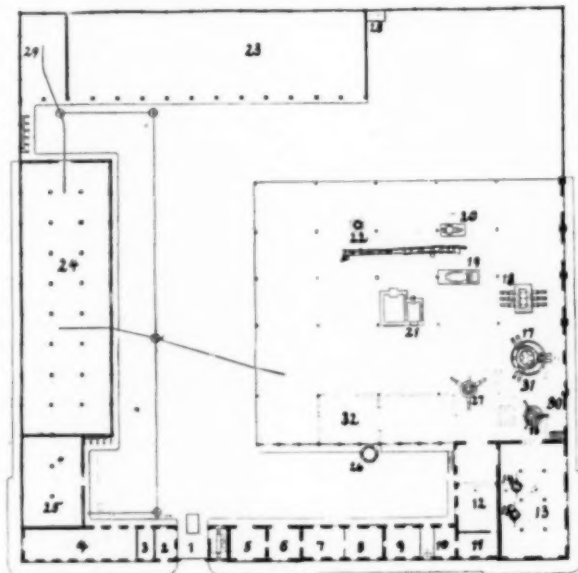

FIG. 4.—PLAN OF STASSANO STEEL WORKS, TURIN.

time of operation to a minimum, so that the furnace may always be used under full charge and the electrical energy utilized to the fullest extent.

On the other hand, this electrical furnace will not overheat the charge in a detrimental way. Indeed, if we express in a few words the chief characteristic features of this furnace, it is an airtight chamber with a thermic source in its center radiating heat at a very high temperature. Evidently the temperature of the chamber will increase and tend to reach gradually that of the voltaic arc, but will not reach it. Experience shows that if the right proportion is used between the charge capacity of the melt-
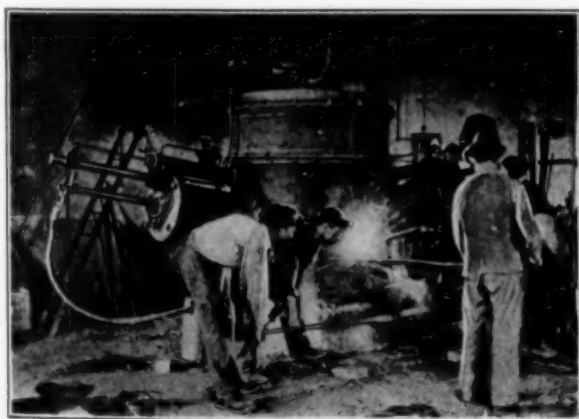

FIG. 5.—100-HP STATIONARY ELECTRIC STEEL FURNACE, STASSANO STEEL WORKS, TURIN.

ing chamber and the quantity of heat produced, the operation proceeds satisfactorily without overheating the charge.

From these premises it seems quite clear that refined iron may be obtained *from ore directly* in this furnace if it is charged with iron ore mixed in the right proportion with a reducing agent and fluxes able to transform the gangue into

slag of the most suitable composition to absorb the impurities in one single operation.

Such a charge will be gradually heated with the exclusion of air. The flux cannot absorb oxygen from the air and maintains its quality also at an elevated temperature, so that it is able to fulfill its mission when the right temperature has been reached. Among the different oxides contained in commercial

FIG. 6.—ROTARY 200-HP FURNACE OF STASSANO STEEL WORKS.

iron ore that of iron is the first one which is reduced. The remaining oxides (SO_2, MnO, MnO_2, CO, MgO, etc.) are, therefore, left without reducing elements and, hence, forced to pass, with the assistance of the flux, into the slag.

In the same way, if pig iron or iron scrap is used, mixed with slag-forming materials, the pig iron and impure iron may be successfully refined in the same furnace, and this is accomplished by starting from predetermined quantities without any necessity of control or tests during the process. The furnace furnishes only the heat to produce the reaction between the different substances of the charge; it does not introduce any other elements.

The reducing element which is used for absorbing the oxygen of the iron oxide is the carbon of common coal or of charcoal, which is the purest of all fossil fuels. When refining pig iron or impure iron, oxide of iron must be added,
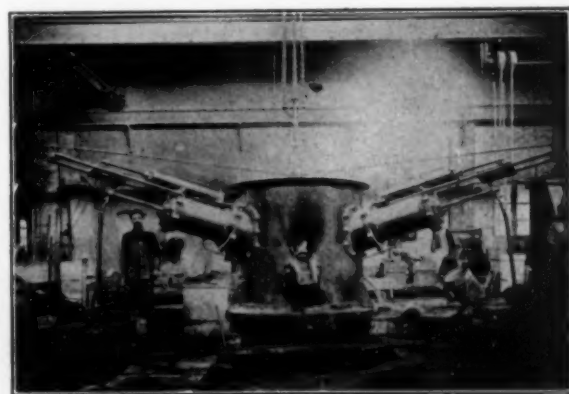
FIG. 7.—TILTING 200-HP FURNACE AT STASSANO STEEL WORKS.

which may be natural or artificial (hammerslag) or powder of rusty scrap. To make the slag, the common fluxes, used in metallurgy, are suitable and may be selected according to convenience and special requirements.

The furnace permits as well the extraction of iron directly from ore as the refining of pig iron and raw iron. Since the design and operation of the furnace exposes the material to the

TABLE D.—MILD STEEL CASTINGS MADE IN REVOLVING AND TILTING 200-H.P. FURNACES IN STASSANO STEEL WORKS, TURIN.

Composition of charge.	ANALYSIS OF CHARGE AND CASTING.					Breaking load kg per sq. mm.	Elongation %
	C %	Si %	S %	Ph %	Mn %		
330. kg Broken iron (picks etc.)	0.245	0.046	0.085	0.034	0.757	...	..
330. Lathe scrap, iron and steel	0.350	0.140	0.050	0.110	0.810	...	..
70. do., rusted	0.300	0.105	0.080	0.056	0.070	...	..
18. Hematite pig iron.	3.800	1.800	0.010	0.015	0.350	Fe	
2.2 Ferro silicon	0.350	51.650	....	0.130	0.360	40.00	..
6. Ferro Manganese..	6.409	0.233	....	0.295	70.732	19.00	..
30. Lime	...	..	...	...	...	..	..
4. Calcium carbide Output	0.200	0.330	0.050	0.038	1.020	..	..
Same charge—Output [1].	0.220	0.100	0.045	0.030	0.420	42	19
Same charge—Output..	0.220	0.170	0.052	0.026	0.500	...	..
Same charge—Output [1].	0.260	0.090	0.048	0.025	0.490	45	17.5
Same charge—Output..	0.260	0.280	0.040	0.035	0.440	...	..
Same charge—Output...	0.250	0.200	0.050	0.035	0.410	...	..
250. Foundry steel scrap.	0.230	0.150	0.042	0.030	0.450	..	..
350. Picks broken.	...	like	above	...	..	..	..
150. Lathe scrap.	...	"	"	...	..	..	..
70. do, very rusty..	...	"	"	...	..	..	..
28. Hematite pig iron.	...	"	"	...	..	..	..
3.43 Ferro-silicon.	...	"	"	...	..	..	..
3.2 Ferro-Manganese..	...	"	"	...	..	..	..
30. Lime.	...	"	"	...	..	.•.	..
4. Calcium carbide Output [1]	0.270	0.130	0.040	0.025	0.399	43	20
Same charge—Output [1]..	0.230	0.280	0.050	0.025	0.460	40	18.5
Same charge—Output..	0.140	0.490	0.045	0.029	0.420	...	..
Same charge—Output..	0.220	0.160	0.040	0.031	0.410	...	..
Same charge—Output [1].	0.200	0.450	0.040	0.026	0.460	42	17
Same charge—Output [1]	0.220	0.170	0.043	0.030	0.390	39.8	20.5
Same charge—Output [1]	0.180	0.110	0.051	0.030	0.440	...	..
Same charge—Output [1].	0.200	0.100	0.040	0.025	0.390	...	..
200. Foundry scrap ...	...	like	above	...	..	..	..
400. Scrap perfored sheets.	0.300	0.130	0.070	0.290	0.210	..	..
150. Lathe scrap.	...	like	above	...	..	..	..
70. " very oxidized	...	"	"	...	..	..	..
60. Hematite pig iron.	...	"	"	...	..	..	..
2. Ferro-silicon.	...	"	"	...	..	..	..
3.6 Ferro-Manganese.	...	"	"	...	..	..	..
35. Lime.	...	"	"	...	..	..	..
5 Carbide—Output [1]	0.300	0.250	0.058	0.035	0.490	45	19.4
Same charge—Output [1].	0.300	0.090	0.055	0.040	0.360	...	..
Same charge—Output [1].	0.280	0.080	0.045	0.035	0.610	...	..
400. Foundry scrap.	...	like	above	...	..	..	..
200. Lathe scrap.	...	"	"	...	..	..	..
150. do. rusted..	...	"	"	...	..	..	..
45. Hematite pig iron.	...	"	"	...	..	..	..
1. Ferro-silicon	...	"	"	...	..	..	..
4.3 Ferro-Manganese..	...	"	"	...	..	..	..
40. Lime.	...	"	"	...	..	.•.	..
5. Calcium carbide Output	0.230	0.180	0.040	0.038	0.400	42	19
Same charge—Output [1].	0.230	0.200	0.045	0.038	0.520	..	..
Same charge—Output [1].	0.220	0.090	0.050	0.035	0.400	..	..
Same charge—Output...	0.230	0.210	0.050	0.035	0.660	..	..
Same charge.	..	..	..	..	..	45	14 [1]
Output [1]							
	0.250	0.230	0.045	0.030	0.680	57	19 [2]
Same charge—Output...	0.220	0.150	0.040	0.035	0.450	..	..
Same charge—Output...	0.300	0.250	0.045	0.030	0.620	..	..
Same charge—Output...	0.250	0.160	0.054	0.033	0.420	..	..
Same charge—Output...	0.230	0.300	0.050	0.025	0.620	..	..

The product was used throughout for castings. The energy consumption was 1.260 kw. hours per kg. of output, this figure being the average for the year 1907.

[1] Ingots molten and annealed.
[2] Ingots forged and annealed.

most elevated temperature in a neutral atmosphere, it is easy to produce iron of the finest and purest quality. Everything depends on the temperature of the bath to render the reactions more active, the slag more liquid, by increasing the basicity and with it the clearing capacity. *Since the atmosphere in the furnace is chemically neutral and the operation may be carried out at will for any length of time, the metal may be nearly entirely freed from all impurities without the risk of pernicious oxidation.*

In the accompanying six tables, A to F, details are given of results obtained in actual practice, which, I hope, will prove the full agreement of practice with my theoretical studies. Indeed, all who have had an opportunity to acquaint themselves with my furnace in operation have become convinced of the soundness and success of the process. The tables A to F are almost self-explanatory and it may only be emphasized here again that they give the results of regular commercial operations at the Artillery Works of the Italian government in

TABLE E.—MANUFACTURE OF SPECIAL STEEL IN THE 200-H.P. REVOLVING AND TILTING FURNACES AT STASSANO STEEL WORKS.

Composition of charge	ANALYSIS OF CHARGE AND OUTPUT.						Breaking load kg per sq. mm.	Elongation %
	C %	Si %	S %	Ph%	Mn %			
400 kg Ondulated sheeting....	0.300	0.130	0.070	0.290	0.210	....	..	..
200. Lathe scraps, very rusted....	0.300	0.100	0.083	0.057	0.070	....	..	..
1.5 Ferro-silicon..	0.350	51.650	...	0.130	0.360	....	..	..
4. Ferro-Manganese	6.409	0.253	...	0.295	70.732	....	..	..
24. Nickel	...	..	..	...	..	Ni 99	..	..
20. Lime.	...	..	..	...	..		..	..
5. Calcium carbide Output	0.180	0.123	0.048	0.007	0.780	Ni 5.600	56	29
Same charge and 5 kg. carbide Output.....	0.165	0.110	0.015	0.007	0.690	Ni 5.56	54.5	30.1
60. kg White pig iron [1]	3.432	0.270	0.083	0.115	2.315	....	..	..
150. Lathe scrap rust'd	0.300	0.105	0.083	0.057	0.070	....	..	..
200. Lathe scrap steel.	0.350	0.140	0.030	0.110	0.810	....	..	..
236. Foundry scrap ..	0.230	0.130	0.030	0.037	0.450	....	..	..
45. Hematite pig iron	3.800	1.800	0.010	0.015	0.350	....	..	..
30. Lime.	...	..	...	...	..		..	..
12. Calcium carbide.	...	..	...	...	..		..	..
9. Ferro-Manganese	6.409	0.253	...	0.295	70.732		..	..
117. Tungstic acid ...	...	..	...	...	..	Cr	..	..
24.5 Charcoal	...	..	...	...	..	Cr	..	..
36.5 Chrome iron	5.800	1.300	0.070	0.028	0.450	70.000	..	..
1.5 Aluminium........	...	..	...	...	..	W	..	..
Output	1.56	0.062	0.012	0.010	0.975	12.900	..	..
						Cr		
200. Hematite pig iron [2]	3.800	1.800	0.010	0.015	0.350	3.500	..	..
16. Tungstic acid ...	...	..	...	...	..	....	..	..
600. Rotten picks.	0.245	0.046	0.085	0.034	0.757	....	..	..
2. Ferro-silicon...	0.350	51.650	...	0.130	0.360	....	..	..
3. Ferro-Manganese	6.409	0.253	...	0.295	70.732	....	..	..
1. Aluminium.	...	..	...	...	..	....	..	..
5. Calcium carbide.	...	..	...	...	..	....	..	..
25. Lime.	...	..	...	...	..	W	..	..
Output	0.960	0.123	0.018	0.018	0.600	1.560	..	..

All the output for ingots.
[1] This charge was made to produce rapid tool steel containing 1.500% C, 0.127 Si, traces of S and Ph, 1.000 Mn, 12.925 W and 3.690 Cr.
[2] This charge was made to produce steel containing 1.1% C, 0.28 Si, 0.07 S, 0.008 Ph, 0.4 Mn and 1.5 W.

TABLE F.—MANUFACTURE OF STEEL INGOTS FOR CASTINGS AND PROJECTILES IN THE 1000-H.P. FURNACES, ONE REVOLVING AND THE OTHER STATIONARY, IN STASSANO STEEL WORKS. TURIN.

Composition of charge.	ANALYSIS OF CHARGE AND OUTPUT.						Breaking load per kg sq. mm.	Elongation %
	C %	Si %	S %	Ph%	Mn %			
2600. kg Lathe scraps, steel [1]	0.300	0.140	0.070	0.110	0.800	...	..	..
1400. Refuse of springs.	0.620	0.490	0.080	0.060	0.970	...	..	..
9.5 Ferro-silicon....	0.350	51.650	..	0.130	0.360	Fe 40.	..	..
21.5 Ferro-Manganese	6.409	0.233	..	0.295	70.732	Fe 19.	..	..
4. Aluminium	..	..	..	...	..		..	..
30. Hammerslags oxide.........	Fe 73.000	1.130	0.150	0.049	1.350	O 25.00	..	..
60. Lime.	..	..	..	...	..		..	..
15. Calcium carbide Product	0.300	0.230	0.037	0.023	0.950	...	58	23
Identical charge Product	0.320	0.210	0.039	0.025	0.880	...	61.	19.8
Identical charge Product	0.310	0.150	0.035	0.022	0.780	...	..	..
Identical charge Product	0.300	0.380	0.040	0.023	0.900	...	57.	21.5
2600. kg Lathe scrap steel [2].	..	like	above	...	..		..	..
1400. Springs. scrap...	..	"	"	...	..		..	..
130. Hematite pig iron	3.800	1.800	0.010	0.015	0.350	....	..	..
4. Ferrosilicon.	..	like	above	...	..		..	..
41. Ferromanganese.	..	"	"	...	..		..	..
4. Aluminium.	..	"	"	...	..		..	..
30. Hammerslags oxide.........	..	like	above	...	..		..	..
60. Lime.	..	..	..	...	..		..	..
15. Calcium carbide Product	0.450	0.085	0.038	0.030	1.215	...	69	18
Identical charge Product	0.420	0.046	0.040	0.027	1.150	...	..	..
Identical charge Product	0.470	0.046	0.041	0.031	1.180	...	71	16.5
Identical charge Product	0.460	0.070	0.039	0.028	1.300	...	70	17

[1] This and the following charges were worked in the 1000-h.p. stationary furnace. The average energy consumption for the campaign was 0.958 kw.-hour per kg.
[2] This and the following charges were made in the 1000-h.p. revolving furnace, the product being ingots for projectiles. The average energy consumption was 0.918 kw.-hour per kg.

Turin and in the steel works "Forni Termoelettriciti Stassano," in Turin.

I have already mentioned that my furnaces may serve as well for the direct extraction of malleable iron from ore as for the purification of pig iron, scrap iron, etc. This shows their great value for countries lacking in fossil fuel, but rich in
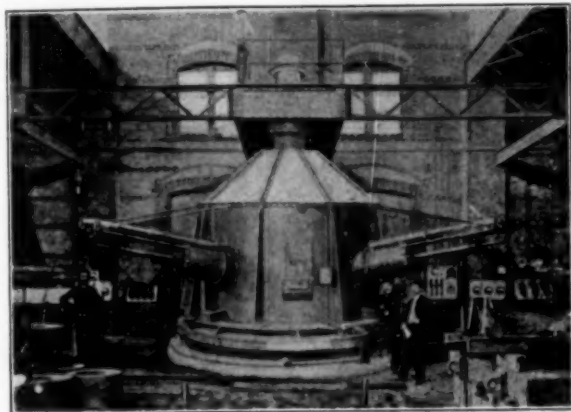

FIG. 8.—ROTARY 1000-HP FURNACE AT STASSANO STEEL WORKS.

water powers. But, although this field of action would be sufficiently large, my electric furnace may also serve an important mission in other countries as a valuable auxiliary to the common iron and steel industry, using blast furnaces, Bessemer converters and open-hearth furnaces.

The progress of modern industry requires iron and steel of highest quality and purity, which cannot be obtained by the common processes or only approximately so, by employing the purest ore, which not only is costly, but scarce.

Under these circumstances, the electric furnace has arrived just in time to help the old iron and steel industry, since its particular properties allow to refine the products of the old furnaces and to carry them to that perfection which the industrial application requires. The consumption of electrical energy is so reasonable that the furnace may even be used conveniently where electricity is produced by coal.

To prevent unnecessary criticism it is well to keep in mind the clear division of the application of the electric furnace into
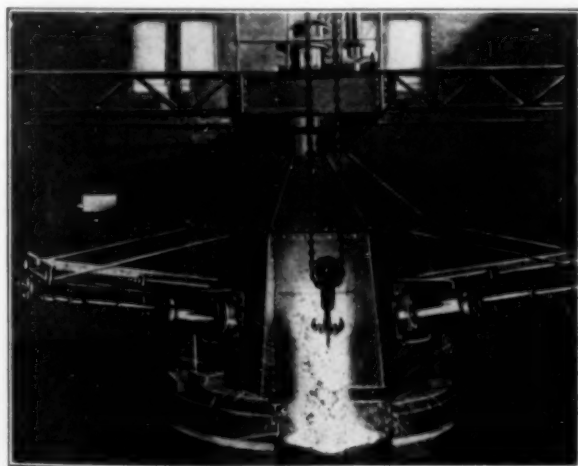
FIG. 9.—CASTING WITH A ROTARY FURNACE OF 1000 HP.

two distinct fields, one being iron-ore reduction in countries where ore and water power are abundant and at a cheap price, while mineral fuel is lacking; the other application is the purification of common furnace products produced in large quantity in the ordinary way by blast furnaces, etc., in order to obtain

a very refined material which heretofore could be produced only with difficulty from the purest ore, of which certainly there is no abundance.

Both plants in Turin, that in the artillery shop and those in the Stassano steel works, are normally treating pig iron and scrap. The latter works are chiefly producing castings of mild steel for automobiles, railway wheels and castings for general mechanical purposes. On various occasions, however, successful conversions of ore into malleable iron and the refining into special steel of finest quality have been carried out.

The erection of the plant "Forni Termo Elettrici Stassano" began towards the end of 1905, and ever since then the furnaces of 100 and 200 hp have been in regular operation, while those of 1000 hp made a sole campaign each, proving the convenience of types of such large size. The only reason why they have not been used continuously in regular operation is that the entire plant has not yet been completed so far as to take care of the output of the 1000-hp furnaces.

The consumption of energy reported in tables C, D and F as the results of regular industrial operation, are average

FIG. 10.—COLLECTOR OF 1000-HP ROTARY FURNACE.

values of the operation extending over one year, or over a complete campaign, as indicated, while the figures in A and B give the consumption as measured in each case by the meters. The average values for a year are higher than the values obtained in single tests on account of various factors which interfere, though they have not directly to do with the strict requirements of the furnaces. After all, the values are all correct and offer a reliable basis for practical calculations.

Further, in examining the figures of the different tables, one has to consider the size of the furnace, which influences the consumption of energy; it is clear that a small furnace will consume more power per unit of output than a bigger one. For instance, in the refining of steel in the 220-hp furnaces at the Steel Works Stassano (average of 1907) 1.26 kw-hours were consumed per kilogram of steel, while 2.3 kw-hours were required with the furnaces of 100 hp.

The construction of the furnace is the same whether it is used for iron reduction or steel refining, with only slight alterations for special purposes. For instance, for refining iron and steel, cold or hot, it is possible to omit the top escape for the gases and the sand and water valves.

Further, with my furnace we are not limited to the treatment of rich ore, but can deal likewise with inferior qualities, be they inferior on account of the percentage of iron or of the content of the impurities.

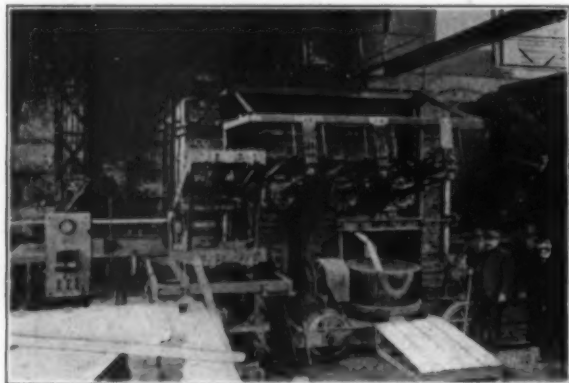Sheet C refers to castings where it was possible to find the

FIG. 11.—1000-HP STATIONARY FURNACE AT STASSANO STEEL WORKS.

exact weight of the output each time; it proves the full recovery of the values of each charge, which is due to the chemically neutral atmosphere in my furnace which impedes any pernicious oxidation and hence any loss of weight.

The possibility and ease of working with predetermined quantities is clearly shown in these sheets, and as the specific consumption of electrical energy per unit of output decreases with the increasing size of the furnace and is within modest limits already with furnaces of 200 hp, the economy of their employment is demonstrated.

The consumption of electrodes, expenses for repairs and insulation and salary expenses are low, as experience has shown. During the long operation in the Artillery Works and in Stassano's Steel Works the consumption of electrodes was not more than 10 kg per ton of output; the expense for lining per ton of output was in the average 10 lira (about $1.93), except some rare special cases where it rose to 14 or 15 lira (about $2.70 to $2.90) per ton. As to the wages, three men will be quite enough for a furnace of 300 hp, and five men, at the utmost six, may attend to a furnace of 1,000 hp when working
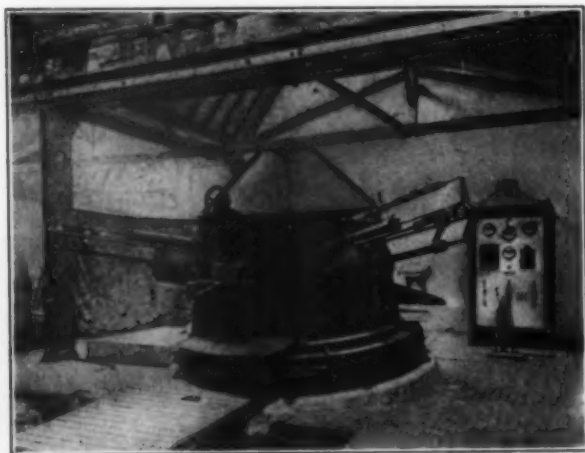
FIG. 12.—ROTARY 250-HP FURNACE OF BONNER FRAESER FABRIK.

with cold material, while for refining steel or reducing ore four men will be sufficient.

Finally a description of the plants using my furnace will be

of interest, since from them the figures were obtained which are given in tables A to F.

The first plant erected was that ordered by the Italian Minister of War for the Artillery Works, at Turin. It contains a furnace of 200 hp (Fig. 3) operated by three-phase currents from the supply network of the Societa Elettricita Alta Italia. An underground cable brings current of 3000 volts to the transformer, where it is reduced to 80 volts between two phases, delta-connection being used. The operation began in spring, 1903, and ever since then the furnace has been in regular operation, making use of the excess of energy produced by water power during the high-water season, which lasts eight months in a year. This results in cheap power for the production of about 2½ tons of steel daily.

The second plant was that of Stassano's Steel Works, at Turin, which at the same time are the only steel works in the world exclusively operated by electricity, and where the whole output is obtained from electric furnaces.

The erection commenced towards the end of 1905 and the plant is now completed. Fig. 4 gives an idea of its arrangement. The first furnace was started in March, 1906, beginning operations before the plant had been finished.

The chief products are castings of iron and steel, while successful trials have been made to produce special steel, which soon will be another branch of the work of the company.
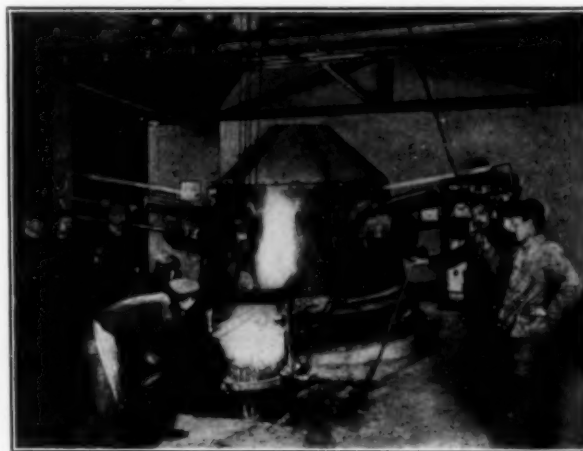

FIG. 13.—ROTARY 250-HP FURNACE OF BONNER FRAESER FABRIK.

At present there are installed two furnaces of my system of the stationary type, each of 100 hp, which are generally used for experiments (Fig. 5), two furnaces of 200 hp each, one tilting and the other rotary (Figs. 6 and 7), and two furnaces of 1000 hp each, one stationary (Fig. 11) and the other rotary (Figs, 8, 9 and 10).

The energy is furnished by the Societa Alta Italia from the public supply mains in form of three-phase currents at 21,500 volts. The voltage is reduced in the works by transformers to 80 volts for the furnaces of 100 hp, which are single-phase, and to 100 volts between two phases, delta-connection, for the 200-hp furnaces, for general power purposes and for lighting, and to 150 volts between two phases (delta-connection) for the 1000-hp furnaces.

The works employ about 300 men. There is a complete hydraulic molding plant, hydraulic crushers, air hammers, a repairing shop and finishing tools and sand blast for the castings.

Like the artillery works, this plant also makes use of the excess of energy produced from water power during the high-water season. The production is, therefore, arranged in such a way that during these eight months one of the two 1000-hp furnaces is also in operation, while during the other four months only the two furnaces of 200 hp are working, besides the other machinery.

Some months ago a rotary furnace of 250 hp (Figs. 12 and 13) has commenced regular operation at the Bonner Fräser Fabrik, in Bonn-on-the-Rhine, Germany, and produces castings of mild steel and special steel. It is fed with three-phase currents from the Berggeist-Brühl Electricity Works, which are steam driven. The voltage supplied is 5500, which is reduced by the transformer near the furnace to 100 volts between two phases.

TURIN, ITALY.

Changes in Magnetic Properties Occurring at the Thermal Critical Points in Steel.

In the article of Dr. H. M. Boylston, published in our July issue, pages 273 and 274, reference was made to two tables giving the results of the use of the method. By an unfortunate mistake these tables were omitted. They are given below.

Table I gives the results obtained by Dr. Boylston and an assistant, using the magnetic method as compared with results obtained by a class of advanced students, using pieces of the same steels and the cooling-curve method.

Table II gives results obtained during the past two years by a large class of students who had no previous experience with the apparatus.

TABLE I.—COMPARISON OF THE MAGNETIC METHOD WITH THE ORDINARY OR COOLING-CURVE METHOD.

Approximate carbon content of steel.	Method.	Ac 3-2-1 Mean	Ac 3-2-1 Max. Min.	Number of Tests	Ar 3-2-1 Mean	Ar 3-2-1 Max. Min.	Number of Tests
1.25%	Magnetic .	773	788 / 759	7	708	711 / 706	7
	Ordinary...	764	781 / 754	4	718	736 / 701	4
		Ac 3-2			Ar 3-2		
0.40%	Magnetic...	780	790 / 770	7	741	750 / 734	7
	Ordinary...	827	830 / 822	3	754	756 / 753	3
		Ac 1			Ar 1		
0.15%	Magnetic...	764	772 / 755	6	764	771 / 758	7
	Ordinary..	768	772 / 764	2	767	783 / 748	3

TABLE II.—RESULTS OBTAINED BY STUDENTS AT HARVARD UNIVERSITY.

Steel Number	Method	Ac 3-2-1	Number of Tests	Ar 3-2-1	Number of Tests
1	Magnetic......	753	72	679	75
	Ordinary......	739	14	688	12
2	Magnetic......	752	131	695	136
	Ordinary......	750	13	695	17

Ferroboron Prize.—The conditions of the prize competition for an award of $500, offered by the Pacific Coast Borax Co. have just been made public by the American Electrochemical Society, which will make the award. The process of making ferroboron must represent an improvement on present methods. We will publish the complete rules of the competition in our next issue.

Silicides for Containers of Acids

At the last meeting of the Faraday Society a paper on new applications of electrometallurgical alloys was presented by Mr. AD. JOUVÉ, consulting engineer in Paris and director of the *Revue d'Electrochimie et d'Electrometallurgie.*

Among the alloys prepared in the electric furnace the most important are those containing iron, and particularly the ferrosilicons.

Electric-furnace ferrosilicons contain a percentage of silicon varying from 20 to 75 per cent, the most usual brands being 20 to 25, 50 to 55 and 70 to 75 per cent.

Their uses are well known to all metallurgists, while the analytical methods for determining them are very numerous, accurate and wholly without complication, being all based on the solution of the substance in alkalies in the presence of an oxidizing agent, such as peroxide of sodium, sodium oxide or free oxygen.

It is a fact well known to analysts that no methods of analysis are based on the effect of acid, except in the case of hydrofluoric acid, ferrosilicons with percentages above 20 per cent being insoluble in acids.

It is this peculiar property, due to silicon alone, which enables one to use ferrosilicon apparatus as containers of acids, since they are practically unaffected by the acid.

Ferrosilicons are not, however, the only substances which possess this property. For, as the effect is due to the silicon, any alloy of a metal with silicon will behave in the same way to a greater or less degree according to the nature of the metal. For instance, that calcium silicide will be unaffected by acid; it is much less affected by acids than metallic calcium.

It seems, therefore, important to investigate whether containers for acids, made from metallic silicides, will be satisfactory for this purpose in other respects. The following facts must be taken into consideration: (1) That these substances are very fragile; (2) they contract considerably on cooling, often breaking in the mold when scarcely solidified and still at a bright red heat; (3) their melting point is low compared with the temperatures occurring in ordinary foundry practice, *e. g.,* the second melting in a coke or gas-heated cupola, and (4) certain of these compounds are powerful reducing agents, so that an effect similar to that produced by aluminium may occur.

In consequence if fusion is carried out in the presence of air (which is necessary for combustion of the coke or furnace gas) there will be a considerable loss of silicon and reduction of the percentage of silicon (especially in rich ferrosilicons, *i. e.,* about 35 per cent) to a point sometimes as low as 15 per cent. But such low-silicon alloys are attacked by moderately strong acids.

Manufacture of Apparatus.—It is not proposed to enter here into complete details of the foundry methods employed, and it may simply be stated that by special arrangements and after many experiments on the mechanical properties of alloys of different natures, it has been possible to obtain, after six years' research, apparatus of all kinds and descriptions.

The first part of the process consists in obtaining melted metal suitable for pouring into molds. The simplest method is to pour the prepared alloys directly from the electric furnace into a mold with a refractory lining. The mixture with other desired elements is then made. In another method, the alloys obtained from the electric furnace are remelted in an oil furnace, or in certain cases in a crucible furnace, and then cast into ingots.

Metals for corrective purposes are added directly to the metal in the casting ladle, usually with aluminium, which raises the temperature of the bath and increases the fluidity.

When the ladle is ready it is carried quickly, by a traveling crane, to prevent cooling, to the mold. The pouring does not require special precautions.

The casting is removed as soon as it solidifies, is turned out

into the warm casting sand and annealed at a bright red heat. It is then ready for use.

Resistance to Acids. — The resistance of the metallic alloys of silicon, which have been called "Métillures," to acids is quite interesting, as will be seen from the following examples. Nitric acid, even as a vapor, such as is obtained at the exit of a bisulphate retort, or when mixed with nitrous acid, does not affect them at all. A striking example of this is given by a pipe which has been submitted for nearly five years to the daily passage of 660 lb. of nitric acid vapor at temperatures varying from 150 deg. to 200 deg. without its loss in weight exceeding a few decigrams in a total weight of a score of kilograms. This loss occurred quite at the beginning of the period and was probably due to a few impurities remaining at the inner surface of the pipe after fusion.

Sulphuric acid has still less effect, and "acids of strength from 20 to 25, known as *petites eaux,* may be concentrated in vessels of this kind by direct heating and continuous evaporation."

Hydrochloric acid is analogous in its action and use has been made of pipes of the above material for carrying and condensing its gases.

Acetic acid and the mixture produced by treating calcium acetate with sulphuric acid are without effect on "Métillures," even in the presence of air.

Resistance to Other Reagents. — An important English firm has obtained figures relating to the resistance of "Métillures" to the action of cyanides, sulpho-cyanides and prussic acid. The results show that the unattackability increases with the percentage of silicon and that for a suitable percentage it is practically negligible.

"Métillures"—20 per cent. Nitric Acid.

No.	Weight in grms.	Change in weight. After 24 hours.	Reaction with Sulpho-Cyanide.
1	6.4410	—0.0392	Violent.
2	5.1669	—0.0047	Slight.
3	8.1524	—0.0037	Moderate.
4	14.5013	+0.0012	Moderate.
5	1.7060	—0.0716	Very violent.
6	1.4941	—0.0034	Very slight.
		After 48 hours.	
1	6.4018	—0.0207	Violent.
2	5.1622	—0.0006	Very slight.
3	8.1487	—0.0032	Moderate.
4	14.5025	+0.0045	Slight.
5	1.6344	—0.0323	Violent.
6	1.4907	—0.0007	None.

Métillures—13 per cent. Sulpho-Cyanide of Aniline.

No.	Weight in grms.	Change in Weight.	Reaction with Potassium Ferri-cyanide.
		After 24 hours.	
1	6.3811	—0.0387	Very violent.
2	5.1616	—0.0065	Moderate.
3	8.1455	—0.0455	Violent.
4	14.5070	+0.0055	Slight.
5	1.6021	—0.0186	Violent.
6	1.4900	—0.0160	Very slight.
		After 48 hours.	
1	6.3430	—0.0675	Very violent.
2	5.1551	—0.0219	Moderate.
3	8.1000	—0.0433	Violent.
4	14.5125	—0.0063	Slight.
5	1.5835	—0.0216	Violent.
6	1.4740	—0.0011	Very slight.

Under the same conditions, iron or any other metal in commercial use would be rapidly attacked, thus preventing its employment. Métillure apparatus, as now constructed, vary greatly in form and dimensions; they are used for evaporating dishes, troughs, right-angled bends, elbows, worms, ventilators, etc. Some of these apparatus weigh about 20 lb. and have a diameter of 1 ft., while others weigh over 1 ton and measure 7 ft. across, while pipes with a diameter of 8 ft. and weighing about ¾ ton are made.

To sum up, the production of a material capable of resisting acids is an acomplished fact, and the principal desiderata are realized. It remains, however, to remedy the unmalleability of these materials. This question is actually being studied, and a solution seems probable in the near future.

Without the electric furnace the high-percentage alloys of metals with silicon cannot be manufactured. Further, without an electric furnace the fusion of high-percentage silicides is

not possible. For when the percentage of Li exceeds 50, the temperature of a coke or gas furnace is not sufficient to permit these alloys to be cast; they will not leave the crucible, but form a pasty mass.

This latest achievement of the electric furnace is timely. For platinum, the most stable industrial metal, becomes more and more rare, and its price increases by leaps and bounds, making its employment a matter of greater and greater difficulty.

Metallurgical Calculations.

By J. W. Richards,
Professor of Metallurgy in Lehigh University.

In the "Introduction" written to the first number of these calculations, in March, 1905, the author outlined the program which he hoped to cover, and mentioned the topics he intended to discuss. The last item on the schedule was "Condensation of Metallic Vapors: Principles involved. Application to the condensation of zinc and mercury." The installment in the last number of this journal covered this topic, and apparently brought the writer to the end of his program.

There are other metals commercially manufactured, however, than those so far mentioned in these pages, and it is worth considering whether any of them furnish problems inviting calculations different from any so far discussed. We have, in fact, covered in Parts I, II and III practically all the metallurgical principles capable of quantitative investigation and expression, and what remains undone is the application of these principles to further special cases.

Metallurgy of Aluminium.

The two essential principles here involved are "differential reduction" as used in the electric furnace purification of alumina, and "electrolytic furnace operation," as illustrated in the decomposition of the alumina by electrolysis in the manner usually practiced. Only the latter problem will be covered here.

Electrolytic Furnace Reduction of Alumina.

The Hall process is beautifully simple and technically admirable. Al_2O_3 is found to dissolve in melted alkaline-aluminium double fluorides; it is as pretty a case of solution, so far as appearances go, as dissolving a spoonful of powdered sugar in a glass of distilled water. The melting point of the fused fluorides is reduced by the solution of alumina, just as that of water is reduced by dissolving salt. In passing the electric current the constituents of the dissolved alumina appear at the electrodes, oxygen at the anode and aluminium at the cathode. The best practical arrangement is to use a carbon-lined pot, with molten aluminium in the bottom as the cathode, upon it a few inches depth of the bath, and dipping into this the carbon anodes. The writer has given most of the technical details of this operation in his treatise on "Aluminium," and Prof. Haber has published extensive laboratory studies of the process in the *Zeitschrift für Elektrochemie.*

With a solvent salt consisting of melted sodium fluoride and aluminium fluoride, such as called for in one of the Hall patents, with alumina dissolved therein, and using carbon anodes, the electrolytic elements of the process are simplicity itself. The bath contains sodium, aluminium, fluorine and oxygen, and the anode is carbon. Under these conditions those elements or compounds will form at the electrodes which cannot further react upon the bath material; in other words, those materials most stable in contact with the bath material or electrodes. A moment's reflection explains what happens, and what must happen. At the cathode, sodium cannot be liberated because metallic sodium reacts chemically on this bath, separating out aluminium; therefore, the electrolytic reducing tendency at the surface of the cathode can only expend itself in separating out aluminium. At the anode, fluorine cannot be liberated because fluorine acts strongly upon alumina even when cold, converting it into fluoride and expelling its oxygen; therefore, the electro-

lytic producing tendency at the surface of the anode will tend to set free oxygen. But oxygen cannot be set free at a carbon surface at a cherry-red heat because of its inevitable tendency to unite with the carbon to form CO. The electrolytic agency at the surface of the carbon anode must, therefore, cause the formation of CO. The whole electrolytic operation results in the removal of Al^2O^3 from the bath and the formation of aluminium and carbon monoxide.

The thermochemical relations, as far as known, agree absolutely with the above explained experimental results. The materials in presence of each other are sodium fluoride, aluminium fluoride, aluminium oxide and carbon. The heats of formation of these, per molecule and per chemical equivalent concerned, are as follows:

(Na, F) $= 109,720 = 109,720$ per chemical equivalent.
(Al, F^3) $= 275,220 = 91,740$ "   "   "
(Al^2, O^3) $= 392,600 = 65,430$ "   "   "
(C, O) $= 29,160 = 14,580$ "   "   "

The heat of formation of carbon tetra fluoride is unknown, but is probably small, since it is so difficult to form.

From the last column, which largely governs the work done by the current, we see that the current does far the least work when it decomposes alumina; in fact, it does still less, by 14,580 calories, because of the assistance rendered by carbon uniting with the oxygen. Now, although the electrical current does not consistently adhere to the doctrine of "least work," yet it does in this case because forced to do so by the chemical relations of sodium, aluminium, fluorine, oxygen and carbon at the temperature of the bath, as explained in the preceding analysis. It is probable that in electrolysis the chemical relations of the possible products control what the current does rather than the thermochemical relations alone, but in most cases the two conditions or controlling circumstances coincide in their influence and lead to identical results. This is the case in the process in question; it is absolutely normal and is explainable by either method of reasoning.

If the operation is run with a small vessel, and correspondingly small current, the heat necessarily evolved by the passage of the current is small compared to the conduction and radiation losses and must be supplemented by outside heating to keep the contents at proper temperature. If the size of the operation is increased in all its items and dimensions, the necessarily generated internal "resistance" heat will suffice to keep the bath at the requisite temperature, when the enlargement is done on a certain scale. If enlarged past this point, too much internal heat is unavoidably generated and means must be used to artificially cool the pot.

Problem 140.

An electrolytic vessel is composed of a block of carbon 25 cm cube, with a cavity 10 cm square by 10 cm deep inside. The cavity has a round carbon, 5 cm diameter, dipping into it. The vessel weighs 30 kilograms; the fused bath in the cavity 2 kg; the carbon immersed in it 0.1 kg. The specific heat of the carbon is 0.5, of the bath 0.3, at the running temperature. An experiment showed that the bath material cooled off, at the working temperature, at the rate of 10° C. per minute, the walls of the vessel at an average rate of 2° C. per minute, when left to cool by themselves.

Required:

(1) The number of watts which must be converted into heat in the vessel in order to maintain it at the working temperature.

(2) Assuming 75 per cent of the theoretical ampere efficiency to be obtained, what amperes passed through the pot will keep it at working temperature if the working voltage is kept at 10 volts?

Solution:

(1) The 30 kg of vessel material losing heat at the rate of 2° per minute, with specific heat of 0.5, gives a heat loss per minute of

$$30 \times 0.5 \times 2 = 30 \text{ Calories.}$$

Similarly, the immersed carbon in the cavity and the bath material itself lose

$$0.1 \times 0.5 \times 10 = 0.5 \text{ Calories.}$$
$$2.0 \times 0.3 \times 10 = 6.0 \quad \text{"}$$

The total heat loss is, therefore, 36.5 Calories per minute.

To maintain the temperature constant the current must furnish this heat, and since 1 watt is 0.239 gram calories per second, the watt energy thus converted into heat must be

$$\frac{36.5 \times 1000}{0.239 \times 60} = \mathbf{2545} \text{ watts} \qquad (1)$$

(2) If all the amperes passing through separated out metal the voltage absorbed in decomposition in the bath would be from the thermochemical heats of formation of chemical equivalent quantities of Al^2O^3 and CO:

$$\frac{65,430 - 14,580}{23,040} = 2.2 \text{ volts.}$$

If 75 per cent of the amperes are efficient, the voltage thus absorbed is

$$2.2 \times 0.75 = 1.65 \text{ volts.}$$

The voltage disappearing in overcoming ohmic resistance will then be

$$10 - 1.65 = 8.35 \text{ volts}$$

and the current which when passed will keep the pot at working temperature will be

$$\frac{2545}{8.35} = \mathbf{305} \text{ amperes.} \qquad (2)$$

The above-used principles are applicable to any kind of electrolytic-furnace operation.

Hard Spots in Steel Castings, with an Account of Certain Diffusion Phenomena.

BY ARTHUR P. SCOTT.
(Concluded from page 286.)

We can now trace, with a very tolerable degree of certainty, the hard spot and blowhole in our roll to their true source.

A lump of ferro failed of perfect admixture in the ladle (the ways in which this could happen will be pointed out farther on) and, in the form of a molten globule or lenticular mass, constantly absorbing iron and gas from the steel, it passed through the ladle-nozzle into the runner, through the gate and into the mold, just as the surface of the molten steel had reached the thrust collar level. Obeying its upward and outward impulse, it flew to the circumference, and was caught in the recess at the point described, where, as can be seen, it would be chilled almost instantly, and where the continued dilution, with absorption and liberation of gas at its interior, led to exactly the condition we have reproduced experimentally in heats 24 and 25.

Since iron and manganese in the molten state are mutually soluble in all proportions, it was now argued that the cause of the sharp dividing line maintained throughout between steel and ferro, was probably rather a function of the relative concentration than of any property inherent in the manganese itself, and that therefore the same phenomena might be expected if a fragment of pig-iron were substituted for the ferro in a heat of soft steel; that if it did, there would be the additional advantage that the more familiar and better defined microstructure of the iron-carbon alloys would render it possible definitely to determine whether or not there occurs any emigration of the carbon before the solidifying point is reached and cementation sets in.

Briefly, two tests made in this way—heats 26 and 27—exhibited exactly the characteristics shown in Fig. 4, the sac being composed of altered pig-iron instead of altered ferro. Also the blowholes were larger than before. Photomicrograph

5 shows a portion of the apex of blowhole A, heat 26. (Micro-photographs 5 and 6 and Fig. 4 will be found on pages 284 and 286 of the July issue of this journal.)

The lower part of the picture exhibits the distinctive appearance of a residual meshwork of cementite, surrounding patches of pearlite. The original pig-iron is seen to be well on its way to the eutectoid stage, and must therefore have suffered much dilution. Next comes the boundary line, quite sharply marked, which defines the partition of steel from iron at the moment of solidification.

Beyond this is a dark band of pearlite, or rather, perhaps, of sorbite, passing sharply into the almost pure ferrite of the original steel. On following it up in the original section, we found places where the dividing line died entirely away, having been obliterated by the progress of the cementation that set in, presumably, immediately upon solidification.

Photomicrograph 6 is taken from the under side of blowhole B, heat 26. At the top appears the ferrite of the soft steel; next, a sorbitic area with a meshwork of ferrite; next, a band of pearlite, and finally, in the lower portion, a fine meshwork of cementite surrounding patches of pearlite. Cementation has been longer at work, and the dividing line has disappeared. Globules of the altered iron that were found in the upper part of the test ingot, shaded into the steel in the same way.

To revert for a moment—there appears in microphotograph 3 and notably in No. 4, a dark band on the steel side of the partition which is more readily understood in view of what has just been said of carbon cementation below the solidifying point. In every one of these cases the short distance the carbon has travelled and the undisturbed parallelism of the outlines of the carbon beach to the parent cliff of iron or ferro—if one may be permitted to imitate Dr. Howe in his graphic use of geographic simile—tend to bear out what has already been indicated, viz., during cooling, down to the point of solidification, the migration is wholly one of iron and gas molecules towards the region of greater concentration and of lower melting point; after solidification the tide turns, as it were, and carbon migrates in the opposite direction.

So thin and so closely adherent to the steel were the walls of the blowholes in heats 26 and 27, that no attempt was made to isolate the altered iron for analysis. Neither could reliable drillings of the steel be obtained. One complete pyramid test was made, however, using pig-iron and rail-steel, and here, as was to be expected, the whole pyramid remained in situ, as in heats 20 to 22 inclusive, and was readily separated and crushed for analysis. The results were as follows:

Heat No. 28. Weight of ingot 1368 g. Weight of pyramid 19.4 g.

	Total. Carbon.	Phosphorus.
Original (gray) pig-iron	3.76	1.56
Altered (gray) pig-iron	2.84	1.07
Regular test—center drillings	.64	.045
Pyramid test—center drillings	.66	.045

Arnold and MacWilliam (Jour. Iron & Steel Inst., 1899-1-85) classify carbon, sulphur and phosphorus in iron as migratory at a temperature of 1000 deg. C. Manganese, they pronounce fixed under the same conditions. They state that the velocities of diffusion of carbon and phosphorus under the conditions they describe are to one another as five to one. This being the case, the phosphorus in our heat 28, would scarcely have diffused sufficiently far into the steel to be included in our drillings of the latter.

By way of more or less crude confirmation of their findings with regard to manganese, we packed three polished blocks, each about 1.5 cm cube in powdered ferromanganese contained in as many 50 cc porcelain crucibles. Cube A was of wrought iron. B was of steel with 0.18 per cent carbon and 0.38 per cent Mn. C was of steel with 0.60 per cent carbon and 0.85 per cent Mn.

We next filled the crucibles to the top with the powdered ferro, tamped them well down and covered each with a seal of well-packed dry fire clay. The three crucibles were then gradually heated in an electric muffle controlled by a Le Chatelier pyrometer, to 1000 deg. C., and held at that temperature (± 40 deg.) for twenty-four hours. During the next three hours the muffle temperature was raised to 1220 deg. C. The current was then cut off, and the furnace allowed to cool.

Chemical and microscopic examination proved conclusively that there had been no migration either of manganese or of carbon, from the ferro to either of the three cubes, which is distinctly interesting in view of the undoubted carbon migration from ferro to steel on cooling from the freezing point, as shown in photomicrographs 3 and 4. But to be considered of significance with reference to the deportment of manganese—iron carbides at high temperatures, the result of our crucible experiment would have to be confirmed—perhaps best by fusing a small core of ferro into an iron barrel, somewhat along the lines suggested for sulphur by T. W. Hogg in the discussion following Arnold and MacWilliams paper (loc. cit., p. 126), and suitably heating the test piece so prepared.

Returning to the pyramid experiments, the writer realizes that the number of these which were carried out is not great, but would remark:

1. That the work has been done in the occasional intervals permitted by duty.

2. That the special Mn test is a hard nut to crack. Great care and patience must be expended in getting at the kernel.

3. That the experiments all pointed so definitely in the same direction as to make mere repetition seem superfluous.

4. That the foregoing descriptions are not selected material. Every bit of work that was done in this connection has been faithfully chronicled here, and every analysis recorded.

5. That all samples for analysis were prepared with the utmost care under the writer's personal supervision, and that the chemical work was performed by competent and experienced analysts.[1]

Practical Considerations.

We are scarcely in a position to say that all superficial hard spots associated with blowholes in steel castings would reveal on closer examination the characteristics described for the subject of this investigation; nor, if we could so assume, would we perhaps be altogether justified in definitely stating that all such hard spots are due to badly distributed ferro. At the same time, there is much well-known evidence of a general character, which in conjunction with the foregoing, enables us to conclude that the number of hard spots and other irregularities caused by imperfect diffusion of the ferro, is far greater than is generally believed.

As is well known, manganese additions to basic open-hearth steel by means of the molten spiegel employed in Bessemer steel-making, are not practicable. Ferromanganese, therefore, is added, either "through the furnace" just before tapping, or else, either cold, or preheated to redness, in the ladle after tapping. The method of addition through the furnace entails heavy manganese loss—a loss which does not seem to be offset by any definite advantage of any kind, because if the ladle additions are properly made, perfect distribution is absolutely assured. There are, however, certain conditions which may be productive of bad results in this respect.

1. If the tapping hole be too large, slag is very apt to come before all the ferro is in.

2. Cases have been known where the mill foreman deliberately waited for nearly all the steel before finishing his manganese addition, with a view to forming a closer estimate of the ladle content, and thereby more nicely adjusting the amount of ferro to be added. This is a most glaring example of "straining at a gnat and swallowing a camel."

3. Occasionally, while carbon and manganese additions are in progress a heavy "boil" is produced in the ladle, accom-

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[1] Messrs. I. C. Mackie, G. MacPherson and W. Tiddy.

panied by such a scorching blast of flame, that the helpers are for a few seconds compelled to desist from their shovelling.

In each of these three cases, some of the ferro falls on top of the slag, in which event it is mechanically held up by the latter, or, if it break through, has lost its impetus, slides gently upon the surface of the steel, fuses, and spreads over it as a distinct layer. This we may safely infer from heat 23 above, and from the general tendency observed in heats 24 and 25.

By this time the ladle is fairly tranquil, so that the layer of molten ferro is more or less undisturbed, the diffusion of iron into it is relatively slow, and perhaps half of the ingots are teemed before merging is effected. As a result, the first half of the heat is short of manganese, while the latter half carries an excess.

If the heat be completely teemed before merging have taken place, the alloy, as soon as it reaches the last ingot-mold, breaks up into globules, which promptly fly to the cooling surfaces and solidify there, forming hard spots.

H. H. Campbell, in his third edition, page 281, supposes a case where a lump of ferro is held up on the slag until shaken through by the disturbance incidental to teeming, etc. The writer has not yet noticed this passage in the fourth edition of Mr. Campbell's work.

4. If the ferro be added in lumps so large that merging does not take place before they can rise to the surface, the tendency will be the same as in cases 1, 2 and 3 just cited.

5. If a lump of ferro strike the bottom of the ladle before the stream of steel does, there is great danger, particularly if the tapping-hole be small, that such lump will chill on the bottom with the ladle skull. In this event, we should have an exact repetition of the conditions of our pyramid experiments, and there is every probability that if the pyramid burst during teeming, some one ingot will receive several planetary nuclei of hard spots and blowholes.

A little care will prevent the occurrence of any of these conditions and, if the tap-hole be periodically formed up with steel pipe; if the ferro be not too coarse—in the writer's experience, ferro that will pass a one-inch square mesh is quite safe—if none of it be added until there is, say, nine inches of molten steel in the ladle; if it be then thrown in as rapidly as possible from three or four shovels at once, so that it is well scattered and all in before the slag starts, an ideal distribution is regularly obtained.

The foregoing remarks have reference strictly to 50 ton heats. With the smaller heats made in so many steel foundries, the writer has had no opportunity of becoming acquainted. Obviously, the smaller the heat, the greater the danger of faulty distribution. Preheating is no doubt of some benefit in such instances; also, the hotter the steel is tapped, the more rapid will the diffusion be.

Before leaving the practical side of the question it may be mentioned that patents have before now been granted to the inventors of certain processes for the production of a hard surface at any desired point in a steel casting by placing a quantity of manganese alloy in the corresponding portion of the mold previous to pouring. Our pyramid experiments go to show that in the conduct of such processes, the most careful attention would have to be given in detail, e. g., the killing of the metal etc., in order to get the hard spots without the blowhole.

Theoretical Considerations.

The formation of blowholes in our pyramid tests seems to outline the method followed by the ferro in fulfilling its well-known function of expelling gases from molten steel, and suggests that pig-iron also has value in this way. We shall hazard no guess as to the reason for the migration of the gas molecules from steel to ferro.

In casting about for an answer to the question, "Why, if our observations are correct, should the iron molecules migrate into the ferro without any reciprocal tendency on the part of the

manganese molecules?" We are struck by an apparent analogy between this phenomenon and certain phenomena observed chiefly for dilute aqueous solutions—phenomena which led to the conception of the osmotic theory by van't Hoff in 1887. This theory, though it had of late years been vigorously attacked by Kahlenberg and other eminent investigators, has still its staunch supporters among some of the most distinguished scientists of our time, and remains, as it has been ever since its formulation, the basis and ground work of our physical chemistry.

In the light of this theory, it is the creed of the physical chemist that just as a given volume of gas exerts, at a given temperature, an outward pressure directly proportional to the number of molecules it contains and due to the impinging of the molecules on the walls of the containing vessel, so, substituting the solvent for an hypothetical aether, the molecules of a substance in solution exert an outward pressure which, for a given solution at a given temperature is directly proportional to the concentration. This homologue of gaseous pressure is termed osmotic pressure. Not only has it been determined that for dilute solutions the product of the osmotic pressure and the volume is proportional to the absolute temperature, so that the equation $pv = RT$, holds for substances in dilute solution as well as for gases, but, further, that R has the same numerical value in both cases.

At any liquid surface, however, whether that surface be free or in contact with the walls of the containing vessel, there is a normal inward pressure, due to surface tension, many times greater than the osmotic pressure, so that the latter, though great, is not evident at the free surface of the liquid and consequently cannot be determined by the simple direct methods used for gaseous pressures. None the less, whether manifest or not, the osmotic pressure is always regarded as present, and is recognized to be the cause of diffusion of substances in solution.

Diffusion, in one aspect, is that process whereby equilibrium is established between two portions of the same liquid which are of different concentrations with reference to the same solute. When, of the same substance, two solutions of different strengths come into contact, diffusion at once sets in, and continues, at a varying rate of speed, until a uniform concentration is reached, and it is customary to regard this diffusion as an incursion from the regions of higher concentration into those of lower concentration. "Just as in gases, we have movements from regions of higher to regions of lower pressure, so in solutions, we have movements from regions of higher osmotic pressure to regions of lower osmotic pressure. Osmotic pressure we then take to be the driving force in the solution." (Walker's "Introduction to Physical Chemistry," p. 171.)

"And, as osmotic pressure is proportional to concentration, it follows at once that the rate of diffusion, which is conditioned by the difference between the osmotic pressures in two adjacent layers, must also be proportional to the difference in concentration." (Ostwald-Muir, "Solutions," p. 102.)

One of the most striking manifestations of osmotic pressure is the following: If we fill with a fairly strong solution of e. g., cane sugar in water, a cell whose walls are permeable to water, but impermeable to dissolved sugar, and place this cell in a vessel containing a dilute water solution of sugar, water will at once commence to pass through the walls into the cell, i e., from the weaker solution to the stronger, raising the level of the liquid in the cell, without any passage of the sugar in the opposite direction, and will continue so to pass, if uninterrupted by any other force, until the liquid in the cell is of the same concentration as that in the outer vessel. The cell behaves as if there were a partial vacuum for water in its interior." (Ostwald-Muir, op. cit. 102.)

The transfer of liquid into the cell is in no way due to the membrane, but it is customary to regard the membrane as essential to the revelation of the ever-present osmotic pres-

sure. On the other hand, in the absence of the membrane, simple diffusion would set in, in which case, as already stated, the osmotic pressure is assumed to manifest itself as a driving force; though, from the nature of the case, experiments on diffusion phenomena are exceedingly difficult of execution, and the precise deportment of osmotic pressure in establishing equilibrium has never been elucidated.

It would therefore be perhaps slightly unorthodox, but certainly not definitely wrong, to assume that in every solution there is always present a partial vacuum with reference to the solvent—this vacuum being, as it were, the expression of the osmotic pressure, and, therefore, other things being equal, proportional to the concentration; and that, when we mingle different strengths of the same solution, the diffusion that takes place does not consist in an impulsion of the more concentrated throughout the weaker portion, but is rather a rush of the solvent from the more dilute portion to satisfy the higher partial vacuum that we may suppose to exist in the more concentrated portion; and that therefore, if it were possible at any moment during the admixture of the two, to instantaneously solidify the whole and differentiate its component parts, we should find separate and distinct portions of the more concentrated solution—already partially diluted by water robbed from the weaker solution—intermixed with portions of the latter, which would have remained unaltered, save for the concentration they have undergone by reason of their loss of water.

We might even go further, and say that each portion maintained its individuality till both were of the same concentration, and that then, and only then, the dividing line between the two disappeared.

As a matter of fact, if we are permitted to follow this line of reasoning it becomes possible, in view of the many analogies between molten metal solutions and ordinary water solutions, to offer a tentative explanation of the phenomena recorded in the first part of this paper.

For, if we look upon ferro-manganese as a concentrated solution of manganese in iron—as it is perfectly legitimate to do—and upon steel as a dilute solution of manganese in iron, and if we assume that such molten solutions possess osmotic pressures—as there seems to be no reason for doubting, more particularly in view of the high temperatures involved, and of the rapidity with which diffusion in such molten solutions is consummated—we may at once conclude, that if a suitable membrane separated molten ferro from molten steel, there would be a passage of the solvent iron through this membrane, from steel to ferro, i. e., from the region of lower to that of higher concentration.

We have already endeavored to show that with a manganese-iron solution, as well as with a carbon-iron solution, such migration of iron did occur, without the intervention of any such membrane.

It might be objected, of course, that ferro-manganese can with equal propriety be termed a solution of iron in manganese, since the terms solvent and solute are here only arbitrarily applied, and that our train of argument is, therefore, worthless. It seems reasonable to suppose, however, that the relatively greater mass of the steel, in which we more definitely regard iron as the solvent, determines the rôle of the ferro in this respect, and that in the instances cited, we are justified in considering ferro-manganese also as a solution of manganese in iron.

At all events, the pyramid experiments are interesting, and more or less unique, as affording a glance at an example of diffusion in molten solution, caught at several stages in the actual process.

Whether or not they have a wider significance, and have a bearing on ordinary diffusion phenomena in liquids, would be difficult to determine.

Dominion Iron & Steel Company,
Sydney, N. S.

Experimental Electric Smelting.

By Louis D. Farnsworth.

This article may be of interest to those making initial experiments with electric smelting. It is based on some experiments done by the writer during the first four months of 1908 at Stanford University, California. The experiments were carried out to learn some of the fundamental principles of electric smelting and to obtain data of their working. The experiments were done more from a mechanical and electrical view point than from a metallurgical, yet they may be of interest to metallurgists.

It may be well to roughly outline the apparatus at hand. Nine old-style, air-cooled lighting transformers were connected in parallel to deliver single-phase current, a total of
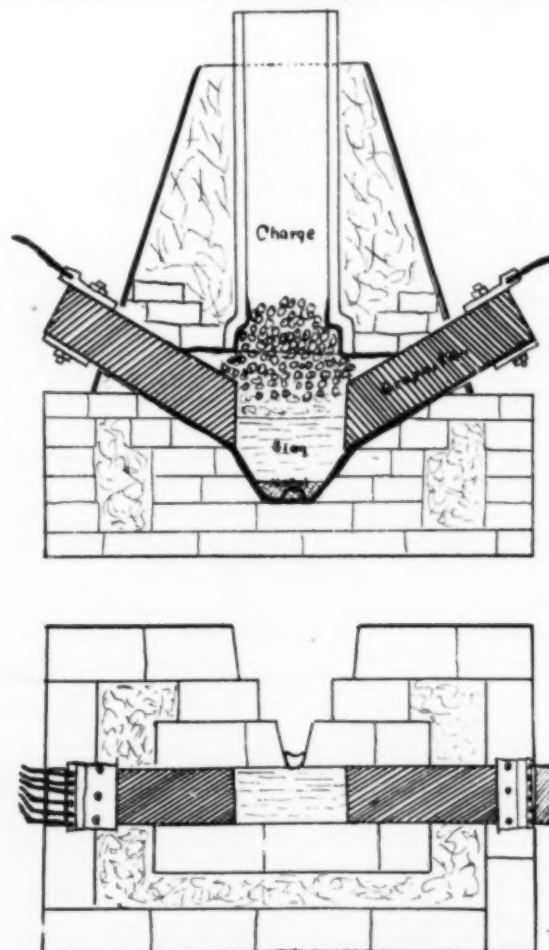

FIG. 1.—ELECTRIC FURNACE.

45 kw, at either 50 or 100 volts. A marble panel from an old university lavatory stall was used for a switchboard. It was not of standard size or shape, but answered the purpose. On this piece of marble were mounted reliable voltmeters and ammeter and necessary oil and knife switches. Two 1000-ampere cables carried the current from switchboard to furnace.

Various styles of furnaces were built and tried. The first one of interest is shown in Fig. 1. It was essentially a crucible, covered by a charging stack, and in the sides of which were inclined two graphite electrodes. The crucible was made of magnesite brick. A good mortar was found to be one part Portland cement, one part silica sand and one and a half parts of fireclay. The inside cavity of the crucible was rectangular in plan, 8 in. by 4½ in., having a depth of 4 in. At the end of the crucible were built two 4½ in. by 4½ in., 30° inclined shafts through which the 4 in. by 4 in. electrodes were operated. Outside the crucible was built a brick shell, the space between

being packed with ashes to retain the heat in the crucible. At the bottom of the crucible was made a small tap hole through which the contents of the crucible could be tapped out.

Directly over the opening of the crucible was placed a terra-cotta sewer pipe which was used as a charging and preheating stack. In this stack the charge was preheated and the ore partly reduced. The entire upper part of the furnace was enclosed in a sheet-iron shell. All space between sewer pipe and iron shell was filled with ashes.

The entire inside of furnace subject to heat was coated with
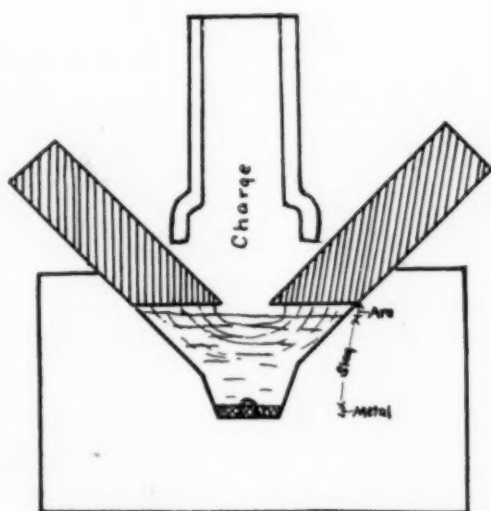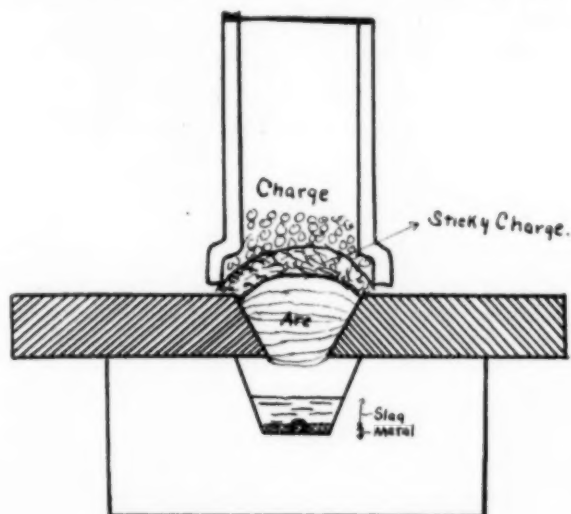
FIGS. 2 AND 3.—MODIFIED FURNACE CONSTRUCTION.

a quarter inch of lining paste. This lining proved to be a good protection to bricks at any temperature obtainable lower than that of an electric arc. It was of carborundum sand, silicate of soda, fireclay and water.

The electrodes were 4 in. by 4 in. graphite. The ends of the electrodes were sawed off on the bias so that they would form the upper part of the ends of the crucible. These electrodes could be readily moved up and down the inclined shafts to regulate the furnace. Electrode holders were cast and machined brass plates suitable to be bolted tight to electrodes. The cables were first soldered into holes in these plates, but due to the heat of the poor contact were melted out. They were then wedged in with steel screws. The cables were placed in their holes and screws pounded in beside them. This scheme made a very satisfactory connection.

The charge used was mangetite ore of 69 per cent iron, with proper mixtures of limestone and coke. In starting the electrodes were placed close together and charging started. The furnace immediately drew current and melted the charge. As the furnace warmed up and slag rose in the crucible the electrodes were drawn farther apart. In starting, the furnace drew about 150 amperes at 50 volts. In 20 minutes the electrodes were 8 in. apart, and the furnace was drawing the full capacity of transformers, 900 amperes. The furnace continued to draw more current. The slag was cooled down by adding more charge.

It was found at this point that the furnace dimensions were not right to fit the transformer capacity. Eight in. drew too much current. In order to retain the slag bath between electrodes and preheat the charge above electrodes, more transformer capacity was needed or the electrodes needed to be
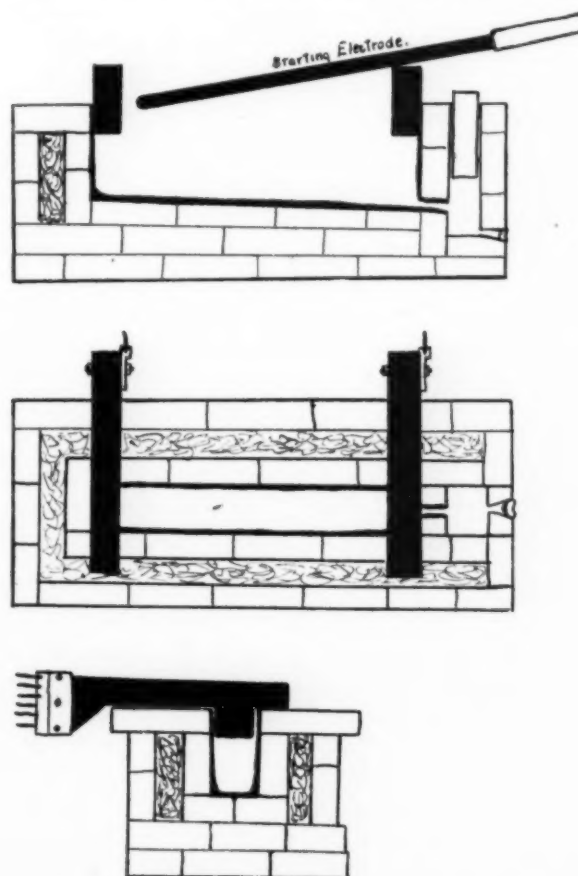

FIG. 4.—FURNACE FOR DETERMINING SLAG RESISTANCE.

farther apart. The design of furnace prevented this. In order to regulate the furnace from this point on the electrodes needed always to be kept at least 1 in. above the slag bath, thus regulating the current with an arc. This arcing does not permit of very long life for the furnace. It is a concentrated intense heat at the wrong place and melts up lining, magnesite brick and in time the whole furnace. By regulating the arc this furnace was found to be able to stand four two-hour runs.

In a two-hour run in which 90 kw-hours were used, 21 pounds of good gray iron was produced. A larger furnace would be more efficient. At the end of a two-hour run it was noted that the hand could be held on any part outside of the furnace except on the electrodes. This shows that the slag bath proposition is all right as soon as the proper dimensions can be obtained. There is lots of opportunity for experimenting along these lines; namely, obtaining data of the resistance of various slags at varying temperature. Some experiments were performed later on to obtain some of this data.

Other types of furnaces tried are shown in Figs. 2 and 3. In the furnace in Fig. 2 the combination of the resistance of arc and the hot charge was used. It was found that a dome of pastey charge prevented the feeding of the furnace without trouble.

In the furnace of Fig. 3 the resistance of the combination of an arc and slag bath was used to regulate. The arc in this case is not nearly so destructive as that in the first furnace as it is applied to the upper surface of the slag bath.

An open-crucible furnace was now built, as shown in Fig. 4, to obtain data on slag resistance. It was essentially a brick trough, 24 inches long by 3½ wide and 6½ deep. This trough was built of Carnegie fire brick, lined with a carborundum paste spoken of above. A brick enclosing wall and heat insulating space was built around the trough as in the first furnace. The bottom of this trough was sloped to one and to draw off the metal. At this end was built a fore-hearth, 4½ x 2¾ inches and 9 inches deep into which the metal could be pocketed. A tap hole was provided here to run off metal at proper intervals. The electrodes were cut as shown in Fig. 4, out of graphite, the key end of which hung over into the trough.

In operating this furnace the trough was filled with charge and the electrodes were embedded in the top of this charge about 12 inches apart and power switched on. The charge was made up of cold broken slag, iron ore, coke and limestone. Due to the cold slag and limestone in the charge the furnace drew no current. A charge of coke and ore or coke alone will start the furnace without any help. With the cold slag charge an auxiliary carbon electrode was used starting a melting zone furnace warmed up until the current flowed between the large electrodes.

of about one-half inch and gradually increasing this as the

In starting this furnace considerable arcing took place underneath the electrodes until good contact was made with slag. These arcs form small cavities in sides of bricks retaining a conductive vapor and drawing considerable current, thus generating heat to enlarge the cavity. This destructive arcing did not continue after the furnace was well started.

When the trough was well filled with slag and the furnace running smoothly, the electrodes being 20 inches apart, the current drawn did not fluctuate as much as 5 per cent. It increased slowly but steadily as the slag reached a higher temperature. Ore dropped into the bath rapidly melted. By charging, the temperature could be kept down and the current kept within the 900-ampere limit. If allowed to go beyond this the bath bubbled and sputtered at contact with electrodes and drew an unsteady current.

It was noted during the run that the highest temperatures were near the electrodes, meaning poor contact between the slag and the electrodes. The rate of charging and melting of charge is a factor in determining the distance between electrodes. If no charging was done the distance between the electrodes in order to draw a given current would have to be great enough to afford sufficient radiation to dissipate the heat generated by passage of current. If the furnace was cooled too much by rapid charging the full current could be picked up by lowering a brick plunger in the fore-hearth and forcing a thin layer of metal back into the furnace. The metal was kept molten in fore-hearth by a layer of hot coke above it.

Iron and Steel Statistics.— The statistics of the American and foreign iron trades for 1907 has just been issued by the American Iron and Steel Association. The total production of pig iron in the United States in 1907 was 25,781,361 gross tons (against 25,307,191 in 1906); in Great Britain, 9,923,856 gross tons; in Germany and Luxemburg, 12,875,159 metric tons. The United States production of bessemer steel rails was 3,380,025 gross tons. We comment on these interesting statistics in our editorial pages.

Annual Meeting of the Iron and Steel Institute.

The greater number of the papers presented at the recent annual meeting of the Iron and Steel Institute were abstracted on pages 290 to 297 of our last issue. We now give abstracts of the balance of the papers.

National Physical Laboratory.

A paper by Mr. WALTER ROSENHAIM, of the National Physical Laboratory, describes the metallurgical and chemical laboratories in the National Physical Laboratory, in London. The department is separated into two divisions; one deals with purely metallurgical research work, the other, which is housed in a newly-erected building, deals essentially with metallurgical chemistry.

In the first division the determination of melting and freezing points of metals and alloys, the determinations of critical points and of entire recalescence curves of steel and other metals, and the study of microstructure are regularly under taken. This division of the department is also frequently called upon to investigate and report upon the causes of failure of parts of structures or machines that have given way or become defective in service.

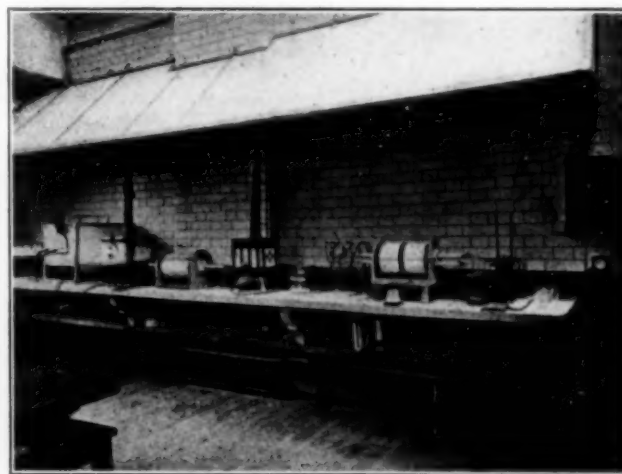In the description of the equipment of this division a novel

FIG. 1.—COMBUSTION APPARATUS.

form of quenching apparatus is interesting. The specimen of metal to be quenched is heated in a horizontal tube of vitreous silica passing through a shorter electric-tube furnace. One end of the silica tube communicates with a receiver and an air pump, the other end through a bent tube with a vessel of water. After the specimen has been heated to the quenching temperature and the heating current has been turned off, the silica tube is exhausted and the water rushes into the hot tube with considerable force and not only chills the specimen, but sweeps it down the tube away from the heated part into the cold end. In this method the specimen is not exposed to oxidation while being heated, and is not subjected to handling or other manipulation tending to disturb the temperature conditions prior to the sudden quenching which occurs at a definite temperature.

In microphotographic work, the etching reagent most frequently used for steel is a saturated solution of picric acid in alcohol, but nitric acid dissolved in amyl alcohol is also found useful. Means for electrolytic etching are also provided.

Steel analysis is one of the chief operations of the second division devoted to metallurgical chemistry.

The determination of *carbon* in steel by the process of direct combustion of fine drillings (which must not be coarse) in a current of oxygen has, after careful comparison with other processes, been adopted as the most reliable and at the same time the most expeditious method. While both the Blair and

the direct-combustion methods are perfectly capable of yielding accurate results, there is a greater liability to accidental error in the former, which also requires more complicated apparatus and occupies more time. The very efficient combustion apparatus used is shown at the right-hand end of the stone bench in Fig. 1.

At the right-hand end of the bench stands a large (60-ft.) cylinder of compressed oxygen, provided with four independent fine-adjustment valves mounted on a fitting specially arranged for this purpose. From each of these valves a stout rubber tube carries the oxygen to a drying and purifying system, which is placed on a wooden shelf underneath the stone bench. The system in question consists of a tower packed with soda-lime, followed by a U-tube packed one-half with soda-lime, the other half with calcium chloride, a separate tower and U-tube being provided for each of the four currents of oxygen. From the U-tube the oxygen is carried in rubber tubes to a set of Dreschel bottles containing sulphuric acid; these are placed in a raised position on the stone bench, so as to be visible to an operator manipulating the fine-adjustment valves on the oxygen cylinders; this operator thus has a guide as to the rate at which oxygen is entering the combustion tubes.

The combustion tubes themselves, four in number, are tubes of vitreous (fused) silica, 28 in. in length and ¾ in. in diameter; they are heated by a four-tube electric furnace, from which they project by 6 in. at each end; these tubes are closed with rubber stoppers at each end, and these remain perfectly cool and are not in any way acted upon, the only requisite precaution being to protect the inner face of the stoppers at the inlet end from direct radiation from the hot part of the tube; this is effected by the interposition of a short spiral of copper gauze.

Originally the farther ends of these silica combustion tubes were packed with finely granular copper oxide, wrapped in asbestos paper, with a view to preventing the oxide from coming into contact with and acting upon the silica tube. This protection was, however, found inadequate; whenever the temperature of the furnace was allowed to rise a little the copper oxide was very liable to fuse and to eat its way first through the asbestos wrapping and then through the silica tube, which it destroyed completely in a few minutes.

The use of copper oxide has, however, been obviated by the employment of platinized silica. It was at first sought to obtain from the regular sources a supply of platinized quartz wool, but this proved unobtainable, and a trial was then made with fragments obtained by pounding up parts of broken tubes of vitrified silica—these have a more or less rough surface owing to the drawing out of enclosed air-bubbles, and when platinized it was found that the platinum adhered well to the surface. Careful comparison showed that the oxidizing action of this platinized silica was quite as satisfactory as that of copper oxide.

Tubes packed with this material, which is readily renewed at suitable intervals, have now been in use for several months with very satisfactory results, the formerly high mortality of silica combustion tubes being entirely checked. It is a curious fact that while the action of copper oxide on these silica tubes is so very rapid, the small quantities of iron oxide which sometimes find their way into contact with the tubes owing to a fragment of steel being spilled from the boat, do not appear to affect the tube at all. In addition to the platinized silica, the tubes contain the usual lead-chromate packing for the absorption of oxide of sulphur.

The furnace in which the combustion tubes are heated is an electric resistance furnace having four separately wound heating tubes fixed within a single large heat-insulating casing of porcelain tube covered with "magnesia sectional covering." These heating tubes were originally made of porcelain and wound with fine nickel wire, but the furnaces made in this manner were found to require rewinding at intervals of about

three weeks, thus causing a serious loss of time as well as trouble and expense.

A winding of platinum foil on the principle of Heraeus was therefore adopted, and this platinum foil was wound on silica tubes to avoid the risk of destruction by cracking, and also to reduce the deterioration of the platinum by electrolytic action as far as possible. The actual winding is so proportioned that when the furnace is at its proper working temperature (about 1000° C.) the resistance of the tubes coupled up two in series, and the two groups in parallel, is about 14 ohms. From a circuit having a pressure of 100 volts this takes a current of a little over 7 amperes, which is found just sufficient to maintain the desired temperature.

For the purpose of starting up when cold, a switch is provided whereby the four tubes can be thrown into series, thus providing a higher initial resistance. This platinum-wound fournace has now been at work for three months without requiring any attention and shows no signs of any change of resistance.

The steel drillings are introduced into the combustion tubes in long, narrow and very light boats made in the laboratory by the aid of a "boatee" or press made by Messrs. Carling to the design of Mr. Stead. The boats actually employed are made very thin in the wall for the purpose of leaving as large a space available for the drilling as possible, since the dimensions of the combustion tubes which electric heating renders desirable are narrower than usual.

At first some little trouble was experienced in making these boats, but the device of coating the molds of the press with vaseline and interposing a piece of thin tissue paper between the molds and the clay has overcome this entirely, particularly when a specially plastic fireclay from Bavaria is used. The boats, when pressed, are dried and the paper is readily removed, but before use the boats are strongly calcined in a muffle furnace so as to be entirely free from carbon.

From the combustion tubes the gases are led through glass cooling tubes which dip into a large vessel of cold water, and thence into U-tubes of special construction filled with pumice saturated with strong sulphuric acid. These U-tubes are provided with glass stoppers at the top, and with a stopcock at the lowest point of the U. Each day these tubes are filled up completely with fresh acid, which is allowed to remain in them for a short time and is then drained away as completely as possible through the tap at the bottom. This leaves the pumice coated with fresh acid every day, while removing any risk of splashing or bubbling that might arise with any excess acid present.

From these drying tubes the gases are led to the potash absorption bulbs, which are of the ordinary Geissler form. These are carried to the adjoining balance room and weighed in the usual manner. In using this apparatus it is found quite possible for one operator to keep the four combustion tubes completely occupied, with the result that in a working day of from six and a half to seven hours one operator can carry out from eight to ten carbon determinations in duplicate (i. e., 16 to 20 separate combustions), although at times of pressure as many as 12 in duplicate have been completed in one working day.

For *phosphorous* determination in steel, the original intention was to adopt the very attractive method of Blair (*Jour. Iron & Steel Inst.*, 1904, No. II, p. 239). While it was found that, as a rule, the results of Blair's method were in excellent agreement with those of the gravimetric methods, thus bearing out the results published by Blair, yet at times unaccountable discrepancies would occur. Sometimes these obviously arose from the fact that a small fragment of zinc had been washed down into the titration flask from the "reductor," and when this was seen to be the case the results were obviously and grossly in error; but less obvious errors appeared when no such occurrence could be detected, and the only conclusion appears to be that errors of this kind are liable to arise from the washing down of particles too minute to be observed.

The reduction of molybdic to molybdous acid, as described

by Blair in the method referred to, was therefore abandoned and a modification of the method was tried, which has been described in various modifications by different writers. In the modification adopted in this laboratory, the yellow molybdate precipitate is obtained in the manner described by Blair in the paper referred to above, but instead of being dissolved from the filter with ammonia, the precipitate is washed first with weak nitric acid (2 per cent) and then with a solution (also 2 per cent) of potassium nitrate until the washings are neutral to litmus paper. The filter paper with the yellow precipitate is then thrown into a flask and maceraated with a little water. A small quantity of 1/20 normal caustic potash (standard) solution is then adtled, in which the yellow precipitate immediately dissolves. The excess of alkali is then titrated back with standard sulphuric acid and phenol-pthalein.

The somewhat complicated method of washing with acid and then with potassium nitrate is generally regarded as necessary, as it is supposed that pure water either slightly dissolves or modifies the composition of the yellow precipitate. A series of comparative tests has, however, shown that this supposition is not, perhaps, well founded, the results obtained when the yellow precipitate is washed with water alone being found to agree closely with those obtained by the more elaborate method.

The volumetric method described above gives results only very slightly lower than those obtained by the more elaborate
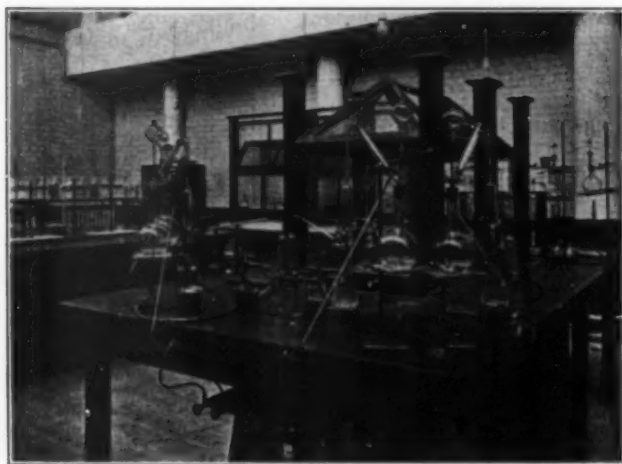
FIG. 2.—APPARATUS FOR SULPHUR DETERMINATION.

and troublesome gravimetric method, the results of the two methods rarely differing more than two duplicate determinations made by either method are frequently found to do. On the whole, however, the results obtained by omitting the potassium-nitrate washing in the volumetric method are found to be very slightly higher than those found when that form of washing is employed, and this difference tends to bring the results still nearer to those found by the gravimetric method. The present practice is to carry out the majority of phosphorus determinations by the volumetric method described above, but in case of abnormal results, and occasionally in normal cases, checking the results by gravimetric determinations.

For *sulphur* determination, a volumetric (evolution) and a gravimetric method are also used side by side. The apparatus used for the evolution method is shown in Fig. 2, where four sets of this apparatus are shown in simultaneous use. It is found that one operator can work with four such sets without delay or inconvenience. The steel drillings are dissolved in the evolution flask of this apparatus in hydrochloric acid of 1.10 specific gravity, the operation being aided by heat, although boiling the acid is avoided.

The evolution flask and entire apperatus are filled, prior to the commencement of the operation, with an atmosphere of

carbon dioxide obtained by passing a stream of this gas, derived from a cylinder of liquid carbonic acid, through the entire apparatus. The evolved gases, aided towards the end of the operation by a further stream of carbonic acid, are bubbled through an absorption flask containing a solution of cadmium acetate strongly acidified with acetic acid (25 grams pure cadmium acetate and 10 per cent glacial acetic acid per liter); after passing this flash the gases pass through a narrow-bore tube of vitreous silica heated to redness by a Bunsen burner with a flat flame, the gases passing finally through a second cadmium acetate absorption flask and then away to the fume chamber.

When the steel has completely dissolved, the contents of the two absorption flasks are mixed and the yellow sulphide of cadmium is filtered off; this is rapid operation since the flask need not be washed carefully—the operation is merely intended to separate the sulphide from the bulk of the absorption liquid. As soon as this has been done the precipitate is washed from the filter back into the original flask and there dissolved in 10 cubic centimeters of standard iodine solution, the action being aided by the introduction of a small quantity of hydrochloric acid. The excess of iodine is then titrated by means of sodium thio-sulphate and starch.

It is to be observed that while this titration can be carried out in the liquid of the absorption flasks without filtration it has been found that this leads to occasional discrepancies in the results. Apparently, particularly in the case of high-carbon steel, the evolved gases carry into the absorption flask something which is capable of absorbing iodine, but which is not sulphur; this disturbing substance can be eliminated by the filtration described above.

There is a close agreement between the results of the evolution method and Archbutt's oxidation method which has been adopted for check and comparison purposes.

Arsenic is determined by "a well-known evolution method." For manganese a colorimetric method depending on the conversion of manganese into permanganate is employed, the well-known "bismuthate" method being used as a check, while silicon is converted into silica and weighed in the usual manner.

For analytic work on alloys and raw materials required in connection with the metallurgical research work, frequent use is made of electrolytic methods of analysis and a special apparatus has been installed for the electrolytic deposition of metals. The system of electrodes described by Sands (*Transactions of the* (Brit.) *Chemical Society*, 1907, Vol. 91) has been adopted and a special arrangement for obtaining the necessary rapid rotation of the anode has been set up, together with facilities for the accurate measurement of current and potential. The installation of a capilliary electrometer is also arranged for, and it will then be possible to use this apparatus for the electrolytic separation of metals by the method of graded potential.

Pyrometer Installation in a Gun Factory.

A paper by Mr. WESLEY LAMBERT, chief metallurgist of the Royal Gun Factory, Woolwich, describes in detail the very elaborate pyrometric installation in the gun section, Royal Gun and Carriage Factories, Woolwich. Pyrometric control extends in these works over the whole thermal treatment, comprising the heating of the steel for forging operations under the steam hammer or hydraulic press, together with the subsequent annealing, oil-hardening, tempering and shrinkage operations.

The platinum—platinum-iridium thermoelectric couple is used throughout. Each of the larger departments of the works has an independent instrument room fitted with a simple indicating instrument. The galvanometer is of the reflecting type and of simple construction; it is a modification of the d'Arsonval galvanometer, devised by Col. Holden.

Two recording instruments are in constant use day and night in the laboratory. The record is a photographic one. Some slight trouble was first experienced through vibration, but this

was successfully overcome by suspending the galvanometer from a tripod in such a manner that the vibration is absorbed by three small spiral springs so arranged as to be in partial compression. The two recording instruments are regarded as the standard instrument of the department.

The following branches are wired up to and are under pyrometric control from the metallurgical laboratory: the heavy forges, the oil-hardening and tempering branches, the case-hardening shop, the drop-forging plant, the lead bath (specimen treatment plant), and the gas muffles throughout the department used by the tool-smiths and other craftsmen. Each of the larger sections has also an independent instrument room with a simple indicating instrument.

Both the indicating and recording types of pyrometer employed are made by James Pitkin & Co., of Clerkenwell, London. The temperature of boiling water is taken as a common zero for the temperature scale of the whole of the instruments comprising the installation. The standard instruments are calibrated by the arrest representing the boiling point of water as zero and the freezing points of "especially pure" tin ($232°$ C.), lead ($327°$), zinc ($419°$), aluminium ($657°$), sodium sulphate ($860°$) and copper ($1084°$).
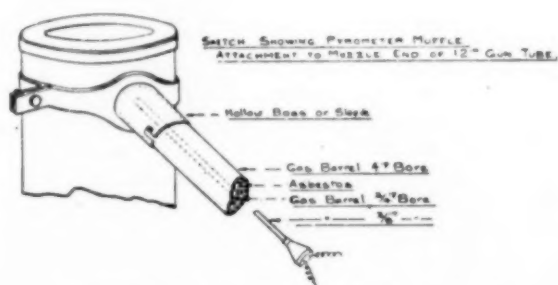
FIG. 3.—MUFFLE CONSTRUCTION FOR PYROMETER.

In order to insure that, as far as possible, the actual temperature of the article heated is ascertained as distinct from the temperature of the furnace itself, the pyrometer tube is sheathed in a circular muffle of non-conducting material in such a manner that the extreme end of the pyrometer, which is in close proximity to the couple itself, shall be in actual contact with the articles. The muffle ensures the absence of any false reading due to the temperature of the gaseous atmosphere of the furnace being conducted down to the thermo-couple.

The protecting muffles at present in use are of two distinct patterns. For use at the forge re-heating furnaces, the temperature of which approximates $1100°$ C. ($2000°$ F.), these muffles are built up of hollow refractory fireclay cylinders or sleeves, similar to those used to protect the swan-neck stopper bar of the ordinary steel casting ladle. These cylinders are luted together and the whole heavily coated with refractory composition, which is then dried and baked.

At the furnaces of the oil-hardening section, there being no occasion for long-sustained high temperature, the protecting muffle is constructed from mild-steel tubing varying according to the size of the furnace from 3 to 6 inch bore, and having centering disks placed at regular intervals along the interior to admit of the insertion of an inner tube concentric with the outer one, and of sufficiently large bore to freely admit the insertion of the pyrometer. The annular space between the inner and outer tubes is tightly packed with well dried asbestos fiber. These muffles vary in length from 3 to 8 feet, as demanded by the nature of the work and the size of the furnace.

As many as five and six thermo-couples are sometimes inserted in the long vertical furnaces of the oil-hardening section employed in heating the larger forgings forming the inner tubes of the heavier guns. These gun tubes in the larger nature of ordnance sometimes exceed 60 feet in length. The furnaces are gas heated, and by means of air ports combustion may be

regulated with great uniformity especially when controlled by a number of thermo-junctions placed at regular ascending intervals in the walls of the furnace.

In this type of vertical furnace the muffles protecting the pyrometer are inserted horizontally through the walls of the furnace, and are of such a length as to extend from the walls to the side of the forging being heated. The muffle is supported at the furnace end in a hollow boss or sleeve clamped on to the forging (Fig. 3) in which the muffle tube fits by a rough bayonet joint, the furnace wall forming the support for the muffle at the exposed end. The pyrometer is then inserted in the muffle, care being taken that the extreme end is brought into contact with the forging.

The top stages of the furnaces of the larger description are provided with a simple telephone in communication with the local pyrometer cabin, thus affording no excuse for the furnace-man leaving the stage when nearing the end of the finishing temperature.

As far as possible, the cold-junction of each couple with the pyrometer leads is maintained "at an equable temperature as nearly as possible approximating the normal atmospheric temperature," (a) by having sufficiently long pyrometers, the wires of the couple being threaded right through from the hot-junction to the head of the instrument, the latter being protected by asbestos screens wherever found necessary; (b) the further precaution is taken of calibrating the whole system with an allowance for the average cold-junction temperature of the various pyrometers in use throughout the system as ascertained by thermometric observations.

Some data are also given on the actual construction of the pyrometers in use.

The method used for the determination of the critical temperatures of any particular ordnance steel is that of plotting differential heating and cooling curves after the manner employed by Carpenter and Keeling at the National Physical Laboratory (*Journal of the Iron and Steel Institute*, 1904, No. 1, p. 224) and only differing from the method described by these two investigators in that no potentiometer is used, the readings being taken direct from an open scale.

Discussing Mr. Lambert's paper, Mr. Wrightson mentioned his experience with the Roberts-Austen pyrometer at the mint. He was of opinion that pressure on two opposing surfaces of iron brought about reduction of temperature, just as in the case of the re-gelation of ice.

Mr. Rosenhain objected to the method of measurement employed on account of the instability of the zero in the D'Arsonval galvanometer, and thought a bifilar galvanometer would obviate such tendency to error. He noted with pleasure the precautions taken to prevent action of furnace gases on the thermocouple. The greatest care must be taken in this respect or results would not be reliable.

Mr. Gledhill said pyrometry was now a most important matter in connection with heavy steel forgings. The 12-in. gun forging required different temperatures according to the varying thicknesses at different parts. The old method of judging by the color was quite useless. The Siemens water pyrometer was useful in the hands of workmen as a check for the pyrometer. A record of treatment in manufacture was desirable.

Dr. Carl Benedicks asked if there were any special arrangements for regulating the temperature of the cold junction. He did not find any mention of this point in the paper.

Mr. W. H. Hadfield drew attention to the possible discrepancies arising from variations in construction of thermocouples. A couple in a silica tube indicated a temperature [fifty] $50°$ C. higher than when enclosed in an iron tube. This might be due to conduction.

Professor Turner insisted on the necessity for calibration under the exact conditions of use in every respect.

It was understood that the author's reply would be communicated later.

Cement from Blast-Furnace Slag.

A paper by Chevalier C. DE SCHWARZ (Liege, Belgium) deals with the utilization of blast-furnace slag. "Taking the total production at all blast-furnace plants in the world, according to recent statistics, at about 50,000,000 tons of blast-furnace slag for the last year, and assuming further that 1 ton of ungranulated blast-furnace slag measures, when broken up, about 20 cubic feet, the blast-furnace slag produced in one year represents a mountain of nearly 1,000,000,000 cubic feet."

In the first part of the paper the author reviews the development of processes for making brick from blast-furnace slag, while in the second part the manufacture of cement is discussed (which is far more profitable than brick making). The author does not agree with the statement which has been made repeatedly that no cement can be made from slag resulting from the manufacture of white pig iron.

"This is incorrect, as may be proved by the fact that Portland cement of good quality can be made from such slag, containing 42 per cent of lime and 4½ per cent of oxide of manganese. The cement made from such slag showed not the slightest trace of instability of volume even after six years' use; it also stood all the tests required by the standards for Portland cement. The manganese oxide in the cement gave it a somewhat brownish color, which, however, was not considered a fault by some customers, but on the contrary was preferred to the ordinary tint for making artificial stones.

"To a certain extent the presence of metal oxides, such as those of iron and manganese, which, as a rule, are higher in slag from white pig iron, makes the cement made from it more apt to resist the influences of sea water. Secondly, the presence of metallic oxides reduces the temperature of fritting necessary for the formation of clinker, thus effecting saving in fuel as a
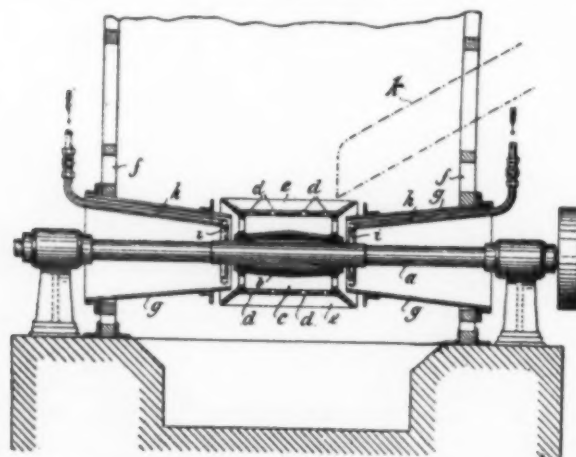
FIG. 4.—LONGITUDINAL SECTION OF COLISEUS APPARATUS.

consequence. A high percentage of lime in Portland cement is not only not necessary, but it is to a certain extent even injurious, as, being to a certain extent free, it causes the cement to 'blow.'"

Of recent processes for making cement from blast-furnace slag, only the process of Colloseus has proven commercially successful. According to this process, solutions of alkaline salts are injected into the hot liquid slag and thus intimately mixed with the latter, the nature and concentration of the injected solutions depending on the chemical composition of the slag, principally on its contents of lime. The quantity of the solution to be injected should be as high as possible; however, the slag thus treated must be perfectly dry after the operation. The salts used for preparing the solutions are principally alum, sulphate of magnesia and nitrate of lime. The concentration, as a rule, varies from 2 to 5 per cent of salt to from 98 to 95 per cent of water.

On account of the great heat the salts are decomposed, most

of the sulphur escaping as sulphurous acid and sulphuretted hydrogen. The slag is chemically and physically changed, and gets the appearance of a porous clinker easily broken up and reduced to powder.

In case slag with a comparatively high percentage of silica and a lower percentage of lime is to be converted into cement, the concentration of the alkaline solution is raised to a maximum of 10 per cent of the salt to 90 per cent of water; besides this a small addition of common cement, clinker rich in lime, has been found beneficial in such cases.

Early difficulties with the apparatus employed have been overcome by the development of improved apparatus, shown in Fig. 4 in longitudinal section and in Fig. 5 in cross-section. The drum b fixed on the shaft a is divided into six interior
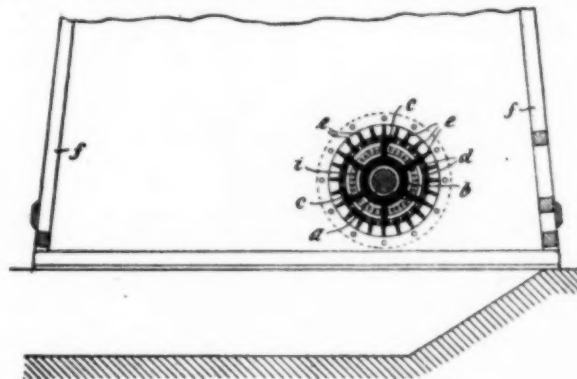

FIG. 5.—CROSS-SECTION OF COLISEUS APPARATUS.

partitions by means of cast-iron ribs c. On the outside the drum is provided with a number of other radial ribs e, running, like the former, parallel with the shaft a. Between the ribs e a number of longitudinal openings d are arranged to provide communication between the interior and the outside of the drum, the latter revolving at the rate of about 650 revolutions per minute. On this drum the hot liquid slag, coming from the blast-furnace, is led by means of a channel k, the whole apparatus being enclosed by a chamber or casing f, made of sheet iron and cooled with water from outside.

Two funnels g (Fig. 6) fixed on the casing f contain the tubes h, the latter leading the alkaline solutions to the revolving drums. At the same time through these funnels cool air is sucked into the interior of the drum along with the alkaline solutions and, the quick revolving drum acting like an exhauster, thrown out together through the openings d with a certain force.

In order to ensure a proper distribution for the entrance of the solutions into the interior of the tambour, two ring tubes i (Figs. 6 and 7) perforated with little holes (shown in Fig. 7) are provided.

The slag, being thus intimately mixed with the alkaline solution, is hurled with great force against the casing f, from where it falls by means of an incline into little bogies to be transported to the crushing-mills.

"From this description it may be seen that the working expenses for making cement from blast-furnace slag according to this process must be exceedingly low, and the initial outlay for erecting such cement works very moderate, as the drying and grinding of raw materials, as well as brick-making and the burning of clinker, is avoided.

"As to the quality of this cement, it may be said that, according to information received, it has stood all the tests prescribed for Portland cement by English, French and German authorities. The cement has been employed for about a year in the erection of viaducts, railway embankments, bridges, houses, etc., showing, up to date, not the slightest trace of damage."

The author finally describes the design of a ball-mill and air separator of German make for grinding blast-furnace cement.

In connection with Mr. F. E. Law's paper on the application of color photography to metallography, which was abstracted on page 296 of our last issue, it is interesting to note that the meeting had an opportunity to view the exhibition of lantern projections of colored photographs of Mr. Law. The great practical value of color-photographs was placed beyond question by the large number of splendid specimens shown, and Mr. Law was the recipient of well-deserved applause and hearty congratulations.

The president expressed the hope that Mr. Law would allow some of his beautiful colored photo-micrographs to be placed with the metallurgical exhibits in the Franco-British Exhibition.

The autumn meeting was then announced to take place at Middlesborough in September next; and the proceedings terminated.

Recent Developments of Induction Furnaces.

A paper by J. HÄRDÉN presented before the Faraday Society on June 23, gives first some notes on the observation of the "pinch effect" in electric furnace practice. (See Carl Hering, this journal, Vol. V., p. 223.) "We have taken observations under working conditions in a 60-kw Kjellin furnace erected in London for experimental work. A small charge of pig-iron, consisting of about one-third of the full capacity of the furnace, was placed in the bath, and a current of 20 kw was employed. As soon as the charge was fully liquid the pinching effect commenced, and the metal was seen to contract at a certain spot, raising the level of the metal on both sides of the pinch, which was sufficient to break the circuit, causing a flash, immediately after which the metal flowed together again, closing the circuit. The level of metal immediately on each side of the pinched area rose about 1½ in. above the normal level of the bath.

"It was found, on examination, that a small piece of slag was burnt into the bottom of the hearth at the point where this phenomenon occurred, thus causing the original reduction of area. Pieces of pig-iron were added to the bath, and as the depth increased the pinching slowly disappeared. It was found that if the original charge was about half of the full charge no pinching effect could be observed."

The author then discusses the "resistance curve of the melt"—that is to say, the curve obtained by taking the voltage across the terminals of the furnace during melting. Supposing we are starting the charge by means of a cold ring of welded or cast-iron. Putting on a full load and keeping the kilowatts constant, we first find that the voltage rises above the normal for full load, and as the ring gets hotter the voltage still gradually rises until the ring becomes a bright red heat.

From that point a decided drop in the voltage is noticed, although the power is kept constant and the weight of the charge is kept the same. As soon as the ring begins to melt the voltage again rises, but does not reach the same value as before the ring was red-hot.

Now let us consider the cause of this result. The furnace is nothing but a transformer, with a short-circuited secondary. This latter must be placed some distance from the primary, owing to the thickness of the lining, cooling chamber, etc. We therefore have a certain amount of magnetic leakage, not only around the primary, but also round the secondary. The secondary is of iron, with comparatively high permeability, and we have therefore introduced an easy path for the lines of the stray field, hence the increased inductive voltage across the terminals. This is to a certain extent compensated for by the lower ohmic resistance of the ring; but as the resistive coefficient of the latter is such as to increase with the temperature, the total resistance, measured across the terminals, will increase with the temperature, but the power factor will be lower during this period, which shows that it is not only the ohmic resistance that is increased but also the inductive resistance.

This is due to the fact that the permeability of the iron is also increased to a certain extent with the temperature; in fact, it rises very rapidly up to a temperature of about 840° C., when the permeability begins to drop very quickly, and reaches zero at about 920° C. In this interval between 840° and 920° the inductive resistance is rapidly decreasing, because the easy path for the stray field is checked, and the voltage across the terminals is consequently lowered. But in the meantime the ohmic resistance is steadily increasing, but this rise is slower than the change in the permeability; therefore, the voltage will rise again, though slowly until the temperature is reached at which the loss by radiation and the heat introduced balance each other.

It may even increase somewhat above this point, owing to oxidation of the charge, but this increase is very slight. This is the reason why some people were misled into believing that the increase of resistance in iron due to heat was not a straight line curve. (It may, perhaps, not be so, but the effect shown on the furnace terminals is certainly produced in the way stated—which can be proved by the wattmeter readings.)

The chief part of Mr. Härdén's paper deals with the Roechling-Rodenhauser modification of induction furnace which has already been described in detail in our January issue (page 10). In the original Kjellin furnace some disadvantages are experienced when dealing with material which has to be refined and treated in very large quantities. For instance, when a charge of three tons or more is to be treated, the section of the bath becomes very large, thus causing a low resistance, whereby the power factor is lowered. If we try to increase the resistance by making the ring wider in diameter and of smaller section, the distance from the primary will be greater and the power factor again lower. Thus it becomes necessary to employ a generator of very low periodicity for such furnaces, which is, of course, undesirable.

Also the processes of desulphurization and dephosphorization are very tedious, as it is difficult to keep the slag sufficiently liquid for such purposes. Nevertheless, this class of furnace will still hold its own, as it forms an almost ideal crucible steel furnace. In this case of crucible steel we have seldom to deal with more than one and a half to two tons at a time, and as it does not pay to use impure raw material, no refining is required, but plain melting and "killing", and for this class of work plain induction furnaces can be provided, which will answer very well at 15 to 25 cycles per second.

But when it is desired to refine say, a material smelted from inferior ores and decarburized in a converter, but still containing up to 0.1 to 0.2 per cent sulphur and 0.05 or more prosphorus, in quantities of five to seven tons, this plain induction furnace would not be so satisfactory.

The author states that about one-half of the power is transmitted to the charge by induction in the rings and the rest of the power through the side plates (which he does not like to be called electrodes in the old sense of the word). As the copper secondary is placed very close to the primary, the leakage field is very much smaller; in fact, three furnaces for one to one and a half tons are now in operation with 50 periods at a lower factor of 0.7 to 0.85, a result which could never be obtained with a plain induction furnace of a similar size, in spite of "bifilar" baths and other devices which have been tried.

"But this is not the chief advantage, as the same result may be obtained by other electrical means. A far more important gain is to be found in the metallurgical possibilities obtained with the new design. We know that for carrying out any refining process in steel we need a sufficiently liquid slag and ways and means of handling the same. This is to a certain extent obtained in some "electrode furnaces," where an arc plays between carbon blocks and the slag "blanker." This, however, in some cases, has proved troublesome, the drawback being that the temperature must be extremely and unnecessarily high at the spot where the arcs are playing, which is not without certain disadvantages to some steels.

"If we try to dip the carbons direct into the molten metal, we

find that they are consumed at once, in such cases contaminating the steel, which is, of course, difficult to avoid. But this is not so in the case of the combined furnace. The conducting side plates before mentioned are of quite a neutral nature; in fact, some plates which had been in constant use, day and night, for three months were so little corroded at the end of that period that the loss of the plates, calculated per ton of steel, was hardly determinable. Part of the power is induced in the rings, thus heating the charge, and the rest passes through the side plates, to such an extent only as experience has proved to be necessary in order to obtain a sufficiently liquid slag.

"The ring-shaped part of the bath is covered with bricks, at a height below the level of the charge in the center injurious to the lining, the rings need hardly any repair during a long run, whereas the rectangular bath in the middle is easily accessible, and can easily be patched out. The lining is simply burnt magnesite or dolomite, mixed with tar, and stamped in hot."

The progress of the operation is described by Mr. Härdén as follows: After the lining is stamped in, the tar is burnt out (either by heating a cast steel ring or pouring a small quantity of pig-iron into the hearth), leaving behind a sintered mass, forming a solid brick or basic lining. The pig-iron is teemed for treatment in the Ressemer converter, and a fresh charge is given, which is taped direct from the converter. It is more economical to burn out the carbon and the silicon in the converter, before refining from phosphorus and sulphur.

The larger furnace at Völklingen will take a charge of four tons. Calcined lime is added to form a suitable slag; this slag also contains about 6 per cent of magnesia. Sometimes a small quantity of fluorspar is also added, to act as a flux, but this is not always necessary. Plate scale from the rolling-mill is added for decarburizing. In this condition the slag will take up the phosphorus very readily, after which it is made more viscous by applying cold lime and drawn off through the slag door by a slight tilting of the furnace.

It is essential for a successful dephosphorization that the charge should be what is called "hot brittle," i. e., have an excess of oxygen, in order to prevent the phosphorus wandering back into the charge again. After removing the slag which contains phosphorus, ferrosilicon or carbon is added, forming SiO_2 or CO, thus depriving the charge of the oxygen. It has been found that the adding of ferrosilicon will shorten the time of the de-oxidation; thus, if power is cheap, the cheaper carbon may be employed, and in the case of dearer power it is better to use the ferrosilicon.

As soon as the dephosphorizing is effected this first slag is entirely removed, and a fresh slag of lime only is formed, which, when the temperature is raised, acts as a desulphurizer in forming iron sulphide. The oxygen is also driven out in this operation, partly by forming calcium carbide, and partly by adding a small quantity of ferrosilicon and eventually some mill scale. After this, the maximum power is given, in order to drive out the last trace of oxygen, and as soon as no more gas bubbles are seen to leave the charge a test piece is taken out and forged. If too soft for the purpose, some coke powder is thrown in until the right proportions are arrived at.

As a rule the charge is finished in one and a quarter to two hours, but if necessary the steel can, without disadvantage, be kept in the furnace for ten hours or more. It is thus possible to treat a material which contains up to 0.1 per cent phosphorus and 0.1 per cent sulphur or more so that a product containing 0.006 per cent phosphorus and 0.02 per cent sulphur and from 0.5 to 0.1 per cent magnesese and 0.01 silicon will be obtained. "As to the power consumption, if the furnace is charged with molten material from the converter, the consumption is from 125 to 150 kw-hours per ton of finished material. This, of course, depends upon the quality of the raw material, but 130 kw-hours may be taken as a good average."

The Roechling-Rodenhauser furnace has been employed for the manufacture of rails and it is stated that they command from 25s. to 45s. per ton more than ordinary rails, owing to their greater durability. Two analyses are given as follows: 0.075 C., 0.03 P., 0.594 Mn, 0.069 S; breaking strength 64 tons per sqare cm., elongation 21 per cent, contraction 28.5 per cent; the other steel contained 0.086 C, 0.018 P, 0.310 Mn, 0.077 S.

Finally a list is given of Kjellin, Roechling, Colby, Heroult and Frick furnaces, in construction, in operation or not in operation. Besides three Kjellin and two Colby induction furnaces, it is stated that there are 15 Roechling-Rodenhauser furnaces (7 in course of construction and 6 working and 2 not working) with a total capacity of 848,400 kg. (An account of the discussion which followed the paper will be found in the monthly letter from our London correspondent elsewhere in this issue.)

Evaporating by Means of Steam.

By Oskar Nagel, Ph. D.

Steam is used for evaporation either directly by passing it through the liquid to be evaporated or indirectly by embedding steam pipes within the liquid.
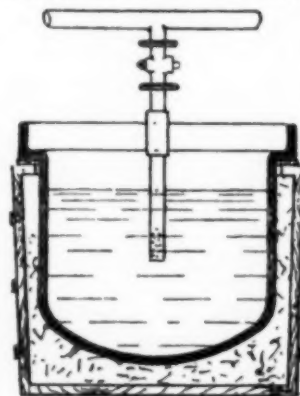
If the nature of the liquid prevents the use of metallic vessels, stoneware vessels are generally used with direct steam. Fig. 1 shows such an arrangement in which the stoneware vessel is placed within another vessel and the space between the two is filled with a non-conductor of heat, like cement.

If the liquid is heated by means of steam coils, the latter may be of various shape, size and material. Spiral pipes are most generally used. Care has to be taken that a moderate inclination prevails throughout, so that the condensed water can run off freely.

FIG. 1.—STONEWARE EVAPORATOR.

To prevent losses of steam and in order to be able to work under pressure it is absolutely necessary to connect the end of the heating coil with a condenser, which naturally has to be watched to prevent the coil from being filled with water.

Steam coils are used for evaporation either in open or closed vessels, depending upon the nature of the liquid and of the vapors formed.

Among closed vessels heated with steam coils we mention stills, extraction apparatus and vacuum-evaporators. Sometimes steam jackets or a combination of steam jackets with steam coils are used in place of coils.

FIG. 2.—VACUUM EVAPORATOR.

The shape of these vacuum apparatus differs considerably. They may be spheroidal, cylindrical or of egg shape. The most suitable form depends on the "foaming" of the liquids during evaporation. Before the vapors leave the apparatus, they must generally pass through a trap provided at the top for catching and retaining any liquid particles. The apparatus is also
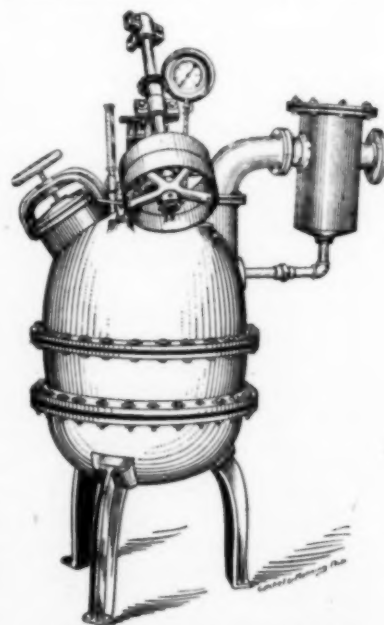
equipped with a discharge opening at the bottom, a thermometer, a vacuum gauge, test cocks, steam, water and liquor valves, etc.

Fig. 2 shows an ordinary type of this apparatus made by Stuart & Peterson. It is preferably made of hard lead for acid solutions. Fig. 3 shows such an apparatus built up of three parts, each of one single piece.
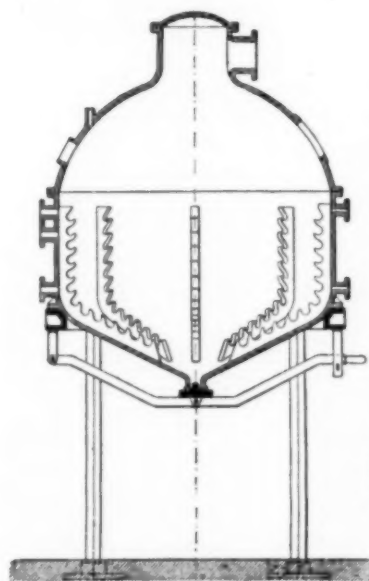
shown in Fig. 4 is successfully employed. In this case the coils are cast into the wall of the vessels, which may also be provided with a stirrer.

According to Dr. H. Claassen the main features of modern methods of evaporation are the use of a high vacuum and the principle of multiple-effect evaporation. The steam evolved in evaporation may be led into another set of steam coils and used
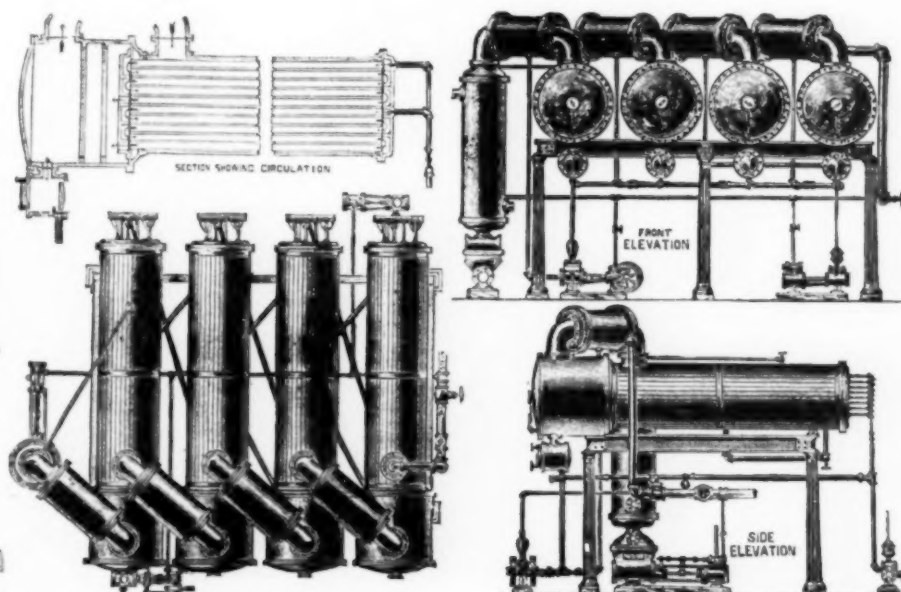

FIG. 3.—EVAPORATOR MADE OF THREE PARTS.

FIG. 5.—YARYAN EVAPORATOR. QUADRUPLE EFFECT.

Formerly steam for the steam coils was directly taken from the boiler, but at present exhaust steam is also used for this purpose. This, however, necessitates a considerable increase of the heating area.

A large heating area, however, cannot always be provided by coils. Special tubular heating structure are, therefore, frequently used, as in the various evaporators to be described below.

The steam has to enter into the vessel as near to the top as possible, while the outlet for the condensed water is provided at the bottom of the vessel. If the steam for heating is to be used at a lower pressure than the boiler steam, a suitable valve for reducing the pressure must be employed.

again for evaporation. Two apparatus coupled together represent a double-effect evaporator; three a triple-effect evaporator, etc.

We will now describe the most important types of evaporators used in the chemical industries.

In the Yaryan evaporator (Fig. 5) the material is kept in very rapid motion so as to be in contact with the heated surface only for a moment. The liquid to be concentrated is fed into one end of 3-in. tube coil, 50 ft. in length; and the rate of feed-
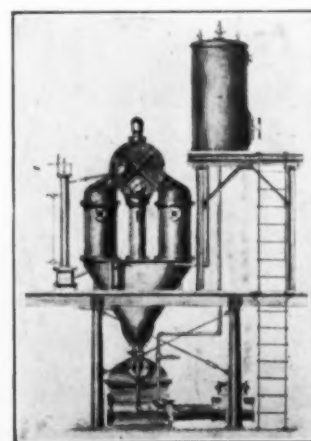

FIG. 4.—STEAM-JACKETED EVAPORATOR.

FIG. 6.—ORDWAY EVAPORATOR.

In stoneware vessels that part which is hit by the entering steam is preferably protected by a shield of sheet metal.

While in metallic vessels joints between different parts are often made by screws, different parts of stoneware vessels are preferably joined by means of Portland cement.

For substances which have a boiling point of over 200° superheated steam has to be used, and in such cases the evaporator

ing is so adjusted that the given heating surface will concentrate the liquid to the desired density. Only in extreme cases is it necessary to return the concentrated liquid for re-evaporation.

Exhaust steam can be used in this system without difficulty. For liquids that require a high temperature for evaporation Yaryans are built that can be used under 100-lb. pressure with perfect safety.

In the operation of this apparatus the steam is led into the cylindrical chamber surrounding the coils in the first effect. The liquid to be concentrated is fed into the first tube of the return bend coils of the first effect in a small but continuous stream, and immediately begins to boil violently. It becomes a mass of spray, containing, as it rushes along the heated tube, a constantly increasing proportion of steam.
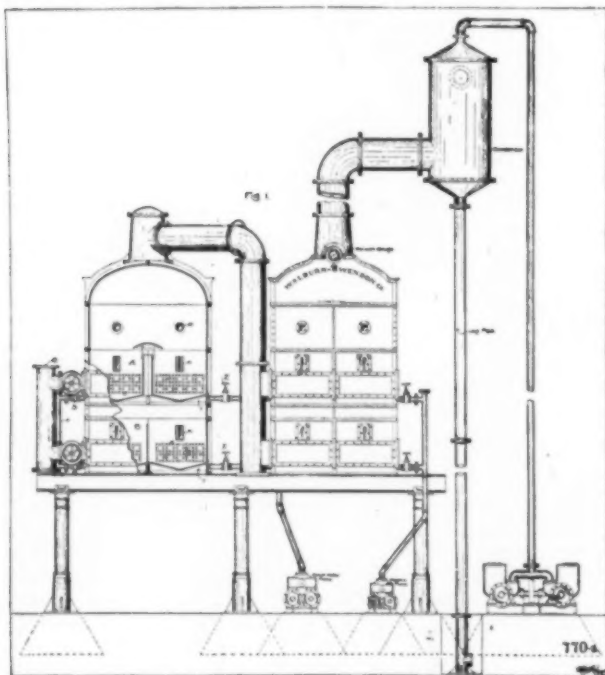
The inlet end of the coil being closed to the atmosphere, and

FIG. 7.—SWENSON EVAPORATOR.

the steam being continually formed, the contents are propelled through the tubes at a high velocity, finally escaping from the last tube of the coil into the separator.

Here the steam or vapor, with its entrained liquid, which has been reduced in volume by the evaporation, is discharged with considerable force against baffle plates which separate the liquid from the steam, causing the former to fall to the bottom and permitting the latter to pass off through an ingeniously con-
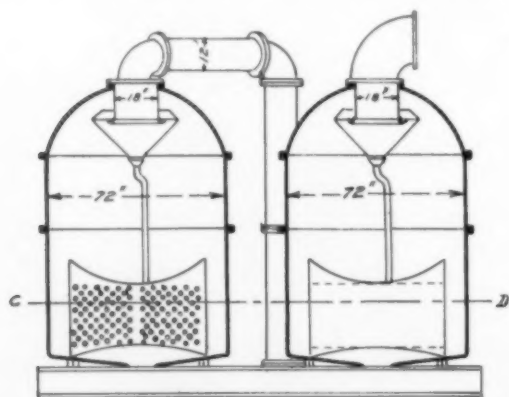
Section A-B

FIG. 8.—ZAREMBA EVAPORATOR. VERTICAL CROSS-SECTION. DOUBLE
EFFECT.

trived catch-all, which effectually removes any remaining liquid, into the chamber surrounding the tubes in the second effect, where its heat is utilized for further evaporation of the liquid.

The liquid from the bottom of the separator of the first effect passes into the coils of the second effect and in it the same process takes place as in the first effect, and so on through the en-

tire series, whether a triple, quadruple, etc., effect is used, the volume of the liquid being constantly reduced in each effect.

The steam from the final effect goes to the condenser and the vacuum pump, a high vacuum being thereby maintained in the separating chamber and consequently in the coils. Hence the boiling point of the liquid is at a lower temperature than that of the surrounding steam, and by the condensation of the steam from the previous effect upon the cooler pipes in the next effect a less perfect vacuum is maintained in the preceding effect.

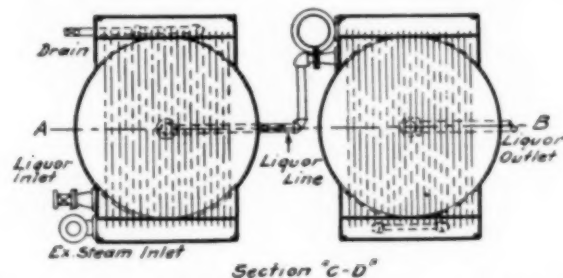Thus we have in the series of effects a gradual reduction in

FIG. 9.—ZAREMBA EVAPORATOR. HORIZONTAL CROSS-SECTION.
DOUBLE EFFECT.

pressure and in boiling temperature, and this automatically adjusts itself, whatever the number of effects, so that the liquid is brought to the boiling point by the steam produced by its own evaporation in the preceding effect. Since a complete condensation of the vapor surrounding the coils in each effect takes place, and the boiling point of the liquid within the coils is below the temperature of the vapor outside, not only sensible heat available on account of the temperature difference outside and inside, but also the latent heat of the condensing vapor is absorbed by the liquid and used for evaporation.

The design of the Ordway concentrator and separator is based on the principle that a liquid concentrated to the crystallizing
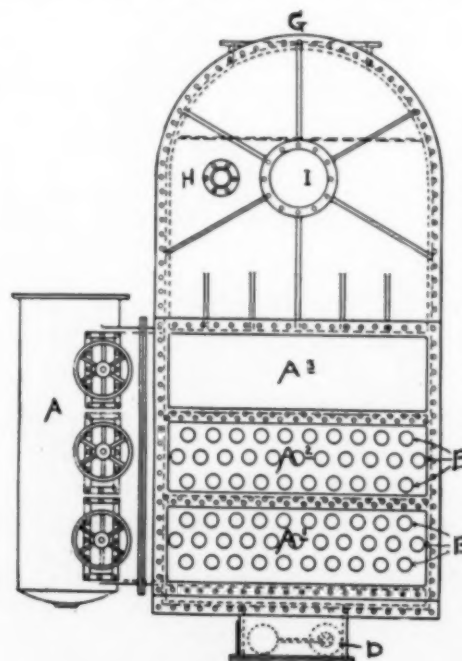

FIG. 10.—NEWHALL EVAPORATOR.

point will, if cooled, precipitate more rapidly and give a more complete separation. While the liquid is being concentrated it comes in contact with heating and cooling surfaces alternately, and in its passage from a cooling surface to a heating surface it passes through a precipitating chamber, where there is sufficient space to collect the crystals for removal.

Should the original liquid be sufficiently cool, it is used as the cooling medium before being fed into the evaporator.

The crystals are continuously removed from the precipitating chamber to a draining tank, which is under the same vacuum as the evaporator, and the drained liquid continually returns by gravity to the evaporator for re-evaporation. When the drain tank is filled with the crystals the circulation is stopped, or changed over to a second draining tank, and the crystals are removed from the first tank in a comparatively dry state.

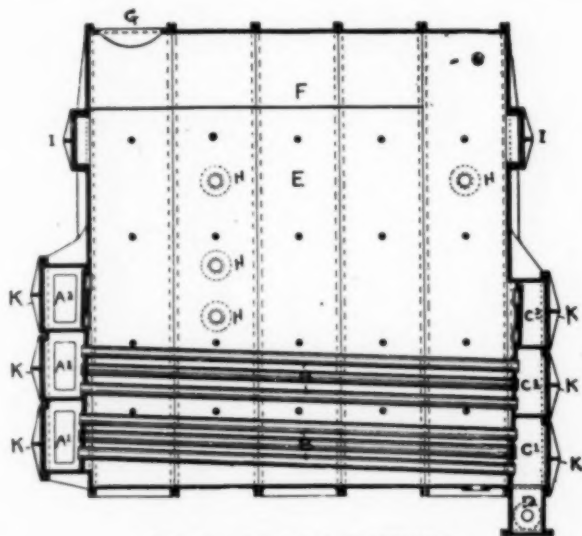The Ordway concentrator (Fig. 6) is made up in sections,

FIG. 11.—NEWHALL EVAPORATOR.

the different sections having the same proportion of heating surface to cooling surface and of vapor chamber to precipitating chamber.

These sections are flanged in such a manner that they may be bolted together to make up one evaporator effect of any size or capacity required, and when an increase of capacity is desired, all that is necessary is to add one or more sections to each effect, thus avoiding the necessity of installing a new plant.

The Ordway is built for single or multiple effect, and is provided with all the convenient appliances of an evaporating plant, such as eye-glasses in each effect, for observing the action of the
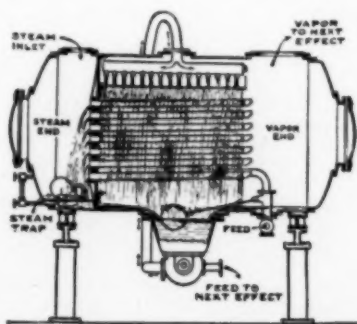

FIG. 12.—LILLIE EVAPORATOR.

liquid while boiling, a tester for testing the density of the liquid, water gauge, automatic feed regulator, condenser, pumps and all intermediate piping.

The submerged tube type of evaporator is represented by (1) the so-called Standard evaporators, consisting of vertically cylindrical shells fitted with vertical tubes, the steam being supplied to the outside of the tubes and by (2) the horizontal tube apparatus which carries the steam inside the tubes submerged in the boiling liquor. A well-known type of the latter is the old Swenson evaporator (Fig. 7) which shows a small double effect on this system. The shell is of heavy cast-iron

plates; tubes of seamless copper or steel, inserted in place by the use of elastic gaskets and packing plates, making possible their ready removal.

The advantages of this type consist of the shallow heating surface, the large area provided for the liberation of the generated vapor, absence of expansion troubles at tube joints, ease of operation, and absolute control of liquor density. When desired the steam chests can be so arranged that any desired percentage of increase of heating surface can be secured by merely adding the necessary tubes.

The latest development in multiple effect apparatus is the Zaremba round body evaporator shown in Figs. 8 and 9, which combines all the advantages of the Swenson heating surface with the structural advantages possessed by the shell of the Standard type. It will be noted that the joints are reduced to a minimum, internal braces are eliminated and that the pans can stand a considerable internal pressure without injury. Furthermore the down-takes are so designed that a much better circulation is obtained giving a heat transmission per square foot of heating surface over 20 per cent greater than is the case with the Swenson. In this connection, it should be borne in mind that the old style horizontal heating surface gives 30 per cent better transmission than the vertical tubes of the Standard evaporator.

The Newhall evaporator as built for chemical works, etc., is shown in Figs. 10 and 11 A is the steam trunk, from which the evaporator draws steam of desired pressure. A^1, A^2, A^3 are compartments from which the tubes are supplied with steam. B are the steam-heated tubes; C, the boxes for condensing water at the lower end of the apparatus; D, a float box with disk valve; E, the space for the vapor and boiling solution; F, a baffle float box with disk valve; E, and outlet G; G, the outlet for vapors and pipe connection betwen this effect and the next one; H, eight glasses to inspect the boiling conditions; I, manholes, and K, removable covers on the steam boxes.
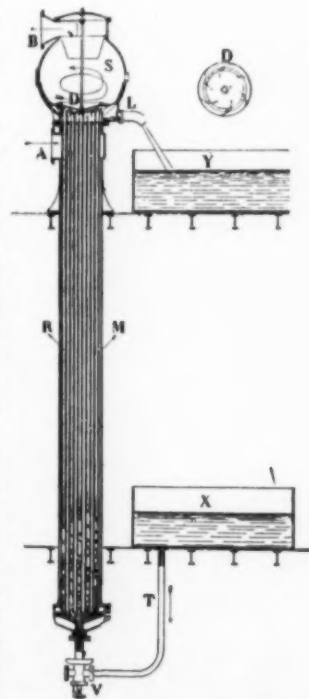

FIG. 13.—KESTNER EVAPORATOR.

A vertical longitudinal section through the body of a Lillie evaporator is shown in Fig. 12. The vapor ends of the tubes are closed. The condensed steam inside the tubes flows back into the "steam end" and thence through a steam trap usually into the steam end of the next coolest body.

The cut shows the circulation of the solution over the tubes as a heavy shower maintained by a centrifugal pump. The circulation is independent of temperature, and on the tubes there is no depth of solution through which vapors formed would have to force their escape.

The Kestner evaporator (Fig. 13) utilizes the principle of film evaporation in a simple manner. The design of this apparatus is such that the film is forced to cling to the heating surface independent of gravity, instead of being forced away from the hot surface by the steam disengaged. This means a very effective use of the heating surface and the possibility of concentration to the desired degree in one passage through the tubes.

In this "climbing film" evaporator the distribution of the film over the heating surface is made automatically by the disen-

gagement of the steam. The tubes in a Kestner evaporator are ordinarily vertical and are about 23 ft. long. The liquid is fed in at the bottom and the supply is so limited that the tubes are practically empty.

At the start the liquid begins to boil in the tubes and very shortly such a violent ebullition occurs that the vapor, occupying many times the volume of the liquid, rushes through the tube at such a velocity that it carries with it against the hot walls of the tube a thin film of liquid. This liquid film, together with the
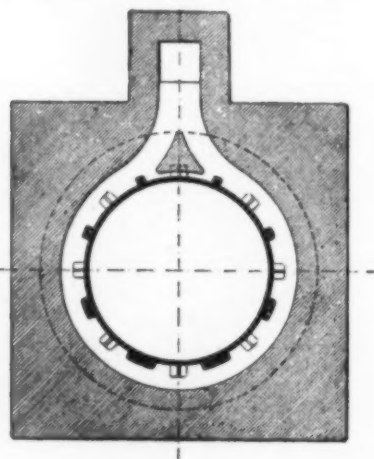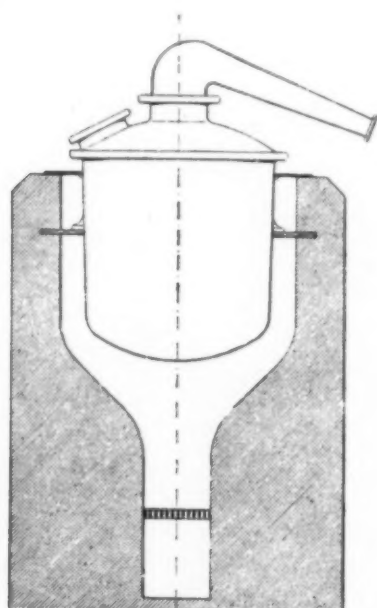

FIG. 14.—CAST-IRON STILL.

vapor, is discharged against suitably designed vanes of a centrifugal separator. In this way the concentrated liquid is whirled against the walls of the vapor belt and the vapor, thoroughly separated from the liquid, passes off to the next pan or to the condenser.

From this description it will be readily understood that the liquor is automaticaly elevated and evaporated in passing, the concentration depending on the amount of liquid admitted. This results in an evaporator essentially different in appearance from others.

* * *

A special case of evaporation is distillation for the purpose of separating liquids from each other. Every distilling apparatus consists, as a rule, of three parts : 1, the vessel containing the liquids to be separated; 2, the cooling apparatus, and 3, the vessel for receiving the distilled liquid.

The setting of a cast-iron still is shown in Fig. 14. Eight lugs cast into the shell of the kettle rest upon an iron ring in the brick work. Eight openings of various size are provided in the ring (those nearest the stack being the smallest), so that the fire gases are forced to play uniformly around the walls of the still. The fire gases pass through these openings to the stack.

On account of the low location of the grate, the flame does not come in contact with the vessel, whereby the life of the plant is considerably prolonged.
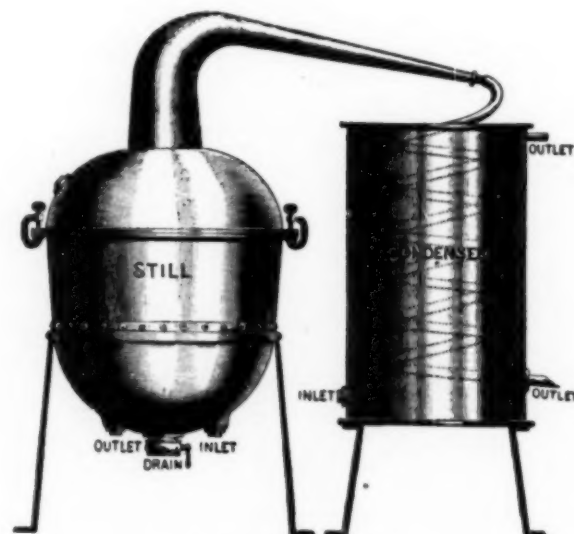

FIG. 15.—DISTILLING APPARATUS.

Many evaporators can be transformed in a simple way into distillation apparatus.

A distilling aparatus of the simplest construction is shown in Fig. 15. The still is heated by a coil; the substance distilling over is condensed in the condenser, which is cooled by water, etc.

A distilling apparatus for making sulphate of ammonia or concentrated ammonia solution from gas-water is shown in Fig. 16. In this apparatus, which was designed by J. L. C. Eckelt, in Berlin, steam jet blowers are used instead of coils, whereby a more thorough mixture of gas, water and milk of lime is ef-
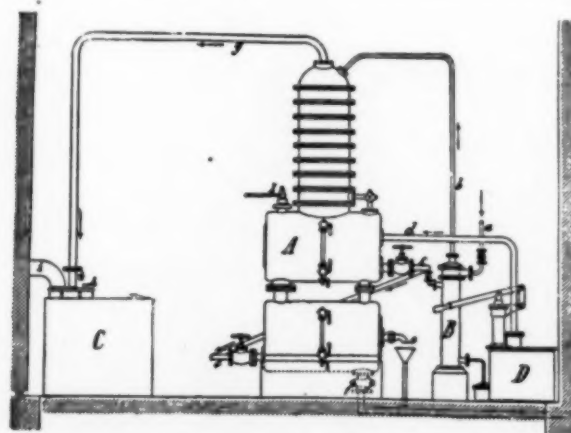
FIG. 16.—DISTILLING APPARATUS FOR SULPHATE OF AMMONIA.

fected, the capacity of the apparatus is increased and the steam is better utilized.

This apparatus consists of three parts, the lower boiler, the upper boiler and the tower on top of the latter. In the manufacture of sulphate of ammonia the ammonia liquor to be distilled flows through pipe *a* from a higher reservoir into the preheater *B* and then through *b* into the tower. Steam enters the lower and upper boilers through valves *c*.

By means of a steam jet blower the gas-water is constantly kept in motion and thoroughly mixed with the milk of lime pumped in from the reservoir D through pipe d. The dissolved ammonia gas rises with the steam through the tower, while the water flowing the opposite way condenses the steam and liberates the ammonia.

The rising ammonia passes through pipe g into the saturating box C and is absorbed by the sulphuric acid contained therein. Foreign gases and vapors are carried by pipe i to a fire place or stack. Through valve l the lime mud is allowed to drop into the lower boiler, from time to time. Through cock f the mud is removed from the lower boiler.

The distilled gas liquor runs off through cock e. When the apparatus is stopped, the stopper k of the box C is removed to prevent the formation of a vacuum in pipe g by condensation of the ammonia gases.

For treating certain substances, distillation in vacuo is frequently applied. In this case the vessel which serves as receiver for the distilled substance is connected to a vacuum pump or to a steam jet blower.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)
The Faraday Society.

At the annual general meeting on the 23d June, the officers and council were elected as follows:

President, Sir Oliver Lodge, F. R. S.; vice-presidents, G. T. Beilby, F. R. S., R. A. Hadfield, Geh. Reg.-Rat., Prof. W. Hittorf, Prof. A. K. Huntington, Lord Rayleigh, O. M., P. R. S., Prof. A. Schuster, F. R. S., Prof. J. J. Thomson, F. R. S.; treasurer, F. Mollwo Perkin, Ph. D.; council, Bertram Blount, F. I. C., A. C. Claudet, M. I. M. M., S. Z. de Ferranti, M. I. E. E., F. W. Harbord, F. I. C., R. S. Hutton, D. Sc., T. M. Lowry, D. Sc., H. F. K. Picard, M. I. M. M., James Swinburne, F. R. S., J. F. L. Vogel, M. I. E. E., and N. T. M. Wilsmore, D. Sc.

The discussion on Mr. J. Härdén's paper (published elsewhere in this issue) on Recent Improvements of the Kjellin and Roechling-Rodenhauser Electric Induction Furnaces was opened by Mr. F. W. Harbord, who was of opinion that the modified form of Kjellin furnace described by the author was an improvement of some value; but how a 7-ton furnace could compete with a modern converter with a capacity of 10 to 14 tons per hour or with a 50-ton open-hearth furnace was not apparent. In fact, the process was a method of refining, and should be employed in co-operation with a converter. This was the proper function of the electric furnace. The etched rail sections which were exhibited did not, in his opinion, prove much in favor of the uniformity of the electric product as compared with open-hearth steel. In all rails there was considerable variation in regard to uniformity. Was this steel actually being used for rails?

From materials as pure as those used in this process there was no difficulty in producing steel equally good in respect of high breaking stress and containing only a trace of phosphorus. He thought the main advantage consisted in its working in a non-oxidizing atmosphere. It was practically a crucible furnace for ton lots instead of pounds. The production of calcium carbide *in situ* was of great interest.

Dr. Harker said he hoped that the 25-kw experimental induction furnace at the National Physical Laboratory in London would soon be in working order. Various researches would then be carried out. Thus the increased resistance of iron at high temperatures would be investigated, and the physical constants of iron, steel and other metals at high temperatures determined. When high current densities were required through molten conductors the "pinch effect" caused serious trouble.

The advantage, for experimental purposes, of effecting the melting of metals and other substances in the inert atmosphere of an induction furnace could hardly be over-rated. Makers of metallic-filament lamps wanted a furnace working *in vacuo;* and for tungsten, which combined with almost any gas brought into contact with it, such a furnace was necessary. He inquired whether the Colby furnace was in use for melting platinum and rare metals *in vacuo.*

Mr. E. Ristori considered that the title of the paper conveyed a wrong impression of the type of furnace described; for this was not purely an induction furnace but a combined induction and resistance apparatus. The inventors had to make use of the resistance principle because an induction furnace was inadequate and could not refine steel. He wished to be informed as to the extent to which refining had been carried out.

Dr. H. Borns asked the depth of the melted metal at the time the "pinch effect" occurred; and also the extent to which "centrifugal rise" is apparent with the Kjellin furnace. He believed that M. Héroult attached much importance to the formation of carbide in his furnace. Was there any true evidence of the production of carbide *in situ?*

Dr. R. Seligman inquired what were the current densities at which the "pinch effect" had occurred. Might not the "stickiness" of melted iron be something more than a mere matter of temperature?

The author, in the course of his reply, stated that the steel described was being used for automotors: and the Prussian State Railways have ordered considerable quantities for points and crossings, paying 50 marks per ton more than for ordinary metal. Calcium carbide was formed *in situ* in the slag, and acted as a sponge in drawing oxygen rapidly from the metal.

There was a good attendance at the ordinary meeting on the 10th June when Dr. Frank read his paper on The Utilization of Atmospheric Nitrogen in the Production of Calcium Cyanamide, and Its Use in Agriculture and Chemistry.

The discussion was opened by Mr. H. Cottrell, who remarked on the difficulty of persuading the British farmer to adopt new manures; but the use of "nitrolim" was supposed by scientific agriculturists and those best acquainted with the values of manures. Artificial nitrogenous manures were alakline and would cure the soil "sickness" caused by ordinary acid manures.

Mr. Walter Reid said he had found from experiment that the manurial value of nitrolim was dependent on the nature and condition of the soil. A clayish sand soil was too light; and moisture was necessary to the utilization of the new manures. He had made experiments on the use of calcium cyanamide in smokeless powders; and found that it distinctly reduced the flame and also lowered the temperature of the gases. Its use as a basis in the production of chemicals hitherto rare and costly should insure the gratitude of chemists to Dr. Frank.

Dr. H. Borns hoped that the author would be able to give further electrical details, viz., materials employed for the furnaces and electrodes, current used, and duration of heating the carbide with the nitrogen. He also made inquiries as to cost.

Dr. J. H. Voelcker defended the attitude of the British farmer in hesitating to adopt new materials before their cost and effect in comparison with the old had been definitely ascertained: and at present the cost of nitrolim to the farmer was unknown. Dr. Voelcker was understood to say that nitrolim could not be procured (commercially): its price was not quoted: and yet cost was the main question, for there was general agreement as to its results on crops. He did not admit that nitrolim was a more beneficial source of nitrogen than some other nitrogenous vehicles. Calcium cyanamide did not keep so well as ammonium sulphate; neither was the nitrogen it contained in such stable combination as that in sodium nitrate. In fact, it lost nitrogen. It was not convenient for mixing with some other fertilizers, e. g., superphosphates; because the admixture sometimes causes a considerable evolution of heat. In view of these difficulties, it was hardly fair to blame the long-suffering farmer for his conservatism.

Mr. H. L. F. Vogel inquired what would be the result if a charge of carbide were not completely acted on by the nitrogen.

Was not evolution of acetylene probable should the powder become moist? The cyanamide produced seemed to contain a very high percentage of lime. Could the author state the degree of purity of the nitrogen produced by the Linde process?

Mr. Leon Gaster asked what was the ratio of the cost of electrical energy to the total cost of production. In making comparisons with other systems it was essential to know this.

The chairman, Dr. F. Mollewo Perkin, mentioned the great utility of calcium cyanamide for the synthetic production of many important organic nitrogenous compounds, evidenced by the several samples on the table. As a basis for the chemical manufacture of such compounds the cyanamide opened out an entirely new direction, and he hoped that full advantage of it would be taken by chemists in this country.

The Aluminium Corporation, Ltd.

Speaking at the recent first annual meeting of the Aluminium Corporation, Ltd., Sir Jas. Sivewright said that in March the first furnace was tapped at Newcastle-on-Tyne, and they had been gradually adding to their furnaces there. The aluminium produced was of very high quality; fully 99 per cent pure. One carbon furnace was in full operation, and there would be three of them. In North Wales the works had been prosecuted with great vigor, and at the beginning of August they would be turning out aluminium at Dolgarrog to the extent of about 1500 tons per annum. When the company started aluminium was selling at from £180 to £200 per ton. The figures in the prospectus were based on aluminium selling at £120 per ton; but it was now about £80 per ton. Still, the directors viewed the situation with perfect equanimity, and he had no hesitation in saying that when their works in North Wales were in operation, and when their other works were completed, the Aluminium Corporation would be in a position, even with aluminium at its present price, to make good profits, and pay substantial dividends.

Royal Society's Conversazione.

At the May Conversazione of the Royal Society Mr. Cowper-Coles exhibited specimens of parabolic mirrors of the same size and shape as those used for searchlights in the Navy made by electro-deposition of silver on a mold made from a cast of an accurately parabolic glass mirror. They are said to give great penetration in foggy weather, and to show objects on which light from them is thrown in greater relief than does the light from an ordinary mirror, and are not so susceptible to breakage as are glass mirrors. One of the mirrors had several direct and ricochet bullet holes in it, but these had not materially detracted from its efficiency. Mr. Cowper-Coles also showed some sheets and tubes of pure electrolytic iron made direct from the pig-iron in one operation by a process of electro-deposition, and without rolling. The tensile strength of the iron is stated to be as high as 30 tons per square inch and it is free from crystalline structure. As far as could be observed, the sheets were of uniform thickness. The cost of power, with electricity at just over one farthing per unit, is about £2 10 0 per ton. Vessels spun from the sheets were also shown.

The National Physical Laboratory showed, among other instruments, a moving coil vibration galvanometer, belonging to a class of tuned galvanometers first introduced by Professor M. Wien. Its novelty consists in the use of the moving coil system. A small moving coil is suspended in the air gap of a strong magnet, and is strongly controlled by a bifilar suspension tightly stretched by a spring. By means of a milled head and screw the tension of the spring can be altered, and the frequency of free vibration of the coil varied between wide limits, bringing its period into tune with that of the source of alternating or pulsating current used, and the instrument will then be about 100 times more sensitive to currents of this resonance frequency than to those with frequencies much different. This instrument ignores the harmonics in an irregular wave form, and allows the measurements to be made on the assumption that a pure sine wave is being used.

Dr. T. E. Thorpe exhibited apparatus and materials used in the determination of the atomic weight of radium; also vessels of glass and quartz colored violet under the action of radium.

Messrs. Johnson, Matthey & Co. had a beautiful collection of laboratory apparatus of transparent fused silica; as well as an exhibit of vessels made of pure iridium.

Messrs. H. G. King and R. Kerr showed standard gages for extremely accurate measurements invented by Mr. C. E. Johansson, of Sweden, by using which, separately or combined, over 80,000 different sizes can be obtained, accurate to within 0.00004 in. at 66° Fahr. The steel is so treated as to minimize any change after hardening. The gages are used in the manufacture of machine parts, tools, and instruments, and for testing. The finish is remarkably fine. Two dry samples rubbed gently together adhere firmly under the pressure of the atmosphere.

A new extensometer shown by the Cambridge Scientific Instrument Co. is a practical instrument without delicate mechanism, made in two separate pieces, the lower one carrying a micrometer screw, and the upper piece holding the spring piece. Both pieces are attached to the test bar by pressing conical points of hard steel rods into center-punch marks in the side of the test bar, made in a special jig. These steel rods are clamped firmly in position, so that the two parts of the micrometer can rotate freely within backlash. A vertical arm forms part of the lower piece and has a knife edge at its upper end. In the upper piece there is a shallow notch which rests on the knife edge. Thus both the upper and lower pieces are held in definite positions. The relative movement of the lower piece carrying the micrometer screw and the tongue is measured, and is proportional to the extension of the test piece. The length of the test piece is 100 mm and readings can be taken to 0.0001 mm. Results can be relied upon to 0.00001 of the length of the test piece.

Market Prices for June.

Tin:—During June tin has shown on the whole a downward tendency since the 2d when it was £130 10 0. Total drop during month is from £130 10 0 to £126 10 0. From the 1st to 3d it rose from £128 to £130 10 0.

Copper:—Flattish. Highest price on 9th, 10th and 11th £58 10 0. Greatest variation for month from £57 15 0 to £58 10 0.

English Lead:—This has declined steadily, but recovered on 12th to £20 5 0, and has been steadily falling since. Total variation £1 0 0.

Hematite:—Fell from £61 on the 1st to £59 10 0 on the 2d and 3d, then steady till the 22d, falling to £58 17 6 on the 23d.

Cleveland Warrants:—Flattish with rising tendency from 4th to 15th. Total variation £1 5 0.

Scotch Pig:—Steady. Total variation 5s. Price on 23d £55 0 0.

Chemicals:—

	£	s	d
Ammonia sulphate, f.o.b. Liverpool	11	17	6
Copper sulphate	21	10	0
Caustic soda, 77 per cent	11	2	6
Bleaching powder, 35 per cent	4	5	0
Antimony regulus	£33 to 35	0	0
Shellac, standarda T. N., orange spots, per cwt.	5	15	0
Carbolic acid, liquid, 97/99 per cent, per gal			11
Creosote, ordinary good, liquid, per gal			2.1/16
Naphtha solvent		2	6
Rubber, Para, fine, per lb		2	11

Rust Prevention.—A method of rust prevention, due to J. Corbett in Birmingham, consists in immersing the article in a hot solution of some phosphate and an iron compound. The metal surface becomes covered with a mixture of ferrous and ferric phosphates, giving a pleasing dull black appearance. The process is adapted for light engineering work, such as cycle frames, gun barrels, stampings and press work.

SYNOPSIS OF PERIODICAL LITERATURE.

Calcium Cyanamide.

Fixation of Atmospheric Nitrogen.—At the last Faraday Society meeting, Dr. Albert Frank, of Berlin, Germany, presented a paper on the utilization of atmospheric nitrogen in the production of calcium cyanamide and its use in agriculture and chemistry. The practical manufacture of calcium carbide in the electric furnace in 1894 by Willson and Moissan furnished Prof. Frank and Dr. Caro with the ideal base required for fixing atmospheric nitrogen in the place of the metallic base which they had previously used (barium) in their experimental search for a commercial method of producing cyanide of potassium for the recovery of gold in mining. As a result of these researches the Cyanid Gesellschaft was founded, which has supplied such a large proportion of the cyanides used in gold extraction in South Africa, Australia and the United States. They also led to the production of calcium syanamide (nitrolim), a genuine substitute for sulphate of ammonia and nitrate of soda for all agricultural purposes, and which can be produced in unlimited quantities wherever limestone, coal and air are available, containing up to 28 per cent of nitrogen.

The only other practical method of fixing atmospheric nitrogen which has been perfected of recent years for similar uses to calcium cyanamide, is known as "lime saltpetre," and has been invented by Prof. Birkeland, of Christiania, but this process, though successful from the scientific point of view, requires considerably more expenditure of power than the Frank-Caro process, and the product possesses, for agricultural purposes, several drawbacks which calcium cyanamide does not. The latter has been so long and extensively tried by agricultural experts all over the world that its behavior is no longer doubtful. It can replace for all purposes sulphate of ammonia and for most purposes nitrate of soda, with the added advantage which neither of the others possesses of being alkaline instead of acid. It does not require any greater precautions in application than the other nitrogenous manures, and can with certain precautions become a useful constituent of mixed or complete manures, as has been determined by Dr. Hall's Rothamstead investigations. It is not so subject to being washed out of the upper soil by heavy rains as either of its predecessors and its effect is more persistent. The lecturer illustrated this part of his lecture with lantern slides of the relative results of the nitrogenous manures, including syanamide, on a variety of crops—wheat, barley, oats, mangels, beets, etc., all showing at least equality with the older and better known manures.

Calcium cyanamide by melting with certain fluxes yields pure syanide of potassium or sodium, and in the form of "surrogate," which can readily be produced near most gold mines, is an efficient substitute for cyanide in the recovery of the precious metals. Ammonia can also be readily and inexpensively obtained from it. Concentrated into dicyandiamide, it is in increasing demand for the manufacture of organic dyes, and its future as a "deterrent" in the form of salts of guanadine to reduce the temperature of explosion in high explosives and prolong commensurately the life of the inner tube of big guns, is assured; it also does away with the flash accompanying explosion, as well as with smoke. Mixed as a powder with other ingredients, calcium syanamide tempers, hardens and cements steel in the most efficient way.

The author then proceeded to describe the practical features of the manufacture of nitrolim. The carbide is first ground to powder in air-tight mills, filled into furnaces which are kept full of nitrogen, and raised to and maintained at a temperature of 800° to 1000° C. for several hours, then allowed to cool slowly, and finally reground into a fine slate-black powder, which is sent out to the farmer in paper-lined bags, containing from 57 to 63 per cent of pure cyanamide or 20 to 22 per cent of nitrogen with about 20 per cent quicklime, 14 per cent of carbon, and 7 to 8 per cent of silex, iron oxide and alumina. To replace the present consumption of Chili nitrate by calcium cyanamide would require something like 800,000 hp, and works are springing up all over the world to produce it wherever water power is abundant and cheap. The first works established for producing and selling 3000 to 4000 tons a year, working for the last three years, were in Italy, at Piano d'Orte (Abruzzi), and are now being enlarged for an output of 10,000 tons. Another works is just being erected at San Marcel (Val d'Aosta), for another 4000 tons, and the great Terni Carbide Works are laying themselves out for the production of some 10,000 tons in the near future. Dalmatia has followed the Italian example at Sebenico, at Fiume (each for an initial 4000 tons), and at Almissa, where 50,000 hp are available, and a further 10,000 tons output is being planned, all the product being required in the Balkans, Hungary and the Mediterranean coast of Africa and Egypt.

France already possesses two works for an initial output of 4000 tons; Switzerland one for 3750 tons; Germany three works with an initial output of 12,500 tons; and one in prospect in the Bavarian Alps for 15,000 tons. The United States Cyanamide Company is erecting a 5000 to 6000 tons works at Ontario, in Canada, to begin with, and another to follow in Tennessee of much larger proportions. The central provinces of India are to be supplied from works on the Nerbuddha River, while the Japanese are erecting a works at the southern end of Kuiskzu Island for an initial 4000 tons. The largest works, however, are due to British enterprise and have just been completed at Odda, in Norway, for an initial output of 12,500 tons with facilities for a prospective increase to 50,000. At the Odda Works the largest Linde plant for obtaining nitrogen from the air ever designed has been erected. These works are supplied with carbide from the adjacent works of the well-known Alby United Carbide Factories Company, with an initial capacity of 34,000 tons, which can be readily expanded to four times that amount by calling further on the available water power at command, up to 80,000 hp. Slides illustrating the features of the several works mentioned were thrown on to the screen.

The author concluded by stating that by the end of the present year works for the production of 45,000 tons of nitrolim would be in full swing, but this would not sensibly affect the market for sulphate ammonia and nitrate of soda, as the demand for nitrogenous manures and products was increasing so rapidly, by over 15,000 tons of nitrogen a year in Germany alone. Both agriculture and the arts and industries seemed capable of absorbing untold quantities of nitrogen in ever increasing amounts and there was no sign of surfeit. In any case, owing to the perfecting of the manufacture of calcium cyanamide, the possibility of Sir William Crooks' pessimistic forecast coming true had become very remote, and mankind was no longer threatened with a shortage in their bread. Diagrams were exhibited of the results obtained in comparative trials on various crops. In the discussion which followed the paper it was brought out that cyanamide is 10 per cent cheaper than ammonium sulphate. Its stability is good; although the lime absorbs moisture, there is no loss of nitrogen. Up to the present its manufacture in one operation (i. e., directly from the elements, without first producing calcium carbide) has not proved successful.

Gold and Silver.

Theoretical Considerations on Silver Ore Treatment with Cyanide.—In the journal of the Chemical, Metallurgical and Mining Society of South Africa, March, 1908, Mr. W. A. Caldecott discusses the reactions involved in the solution of silver from its ores, basing his views on a study of the properties of artificially prepared silver sulphide. The primary reaction, according to him, may be taken as the following: $Ag_2 S + 4 Na Cy = 2 Na Ag Cy_2 + Na_2 S$. When a certain amount of silver has been dissolved according to this reaction, an equilibrium is established and solution ceases. It depends upon the amount of soluble sulphide in solution, how far the reaction proceeds before this equilibrium is reached, be this soluble sulphide derived

from silver or other sources. The amount of free cyanide present is also a determining factor. The author gives the following table of results obtained from a series of argentiferous sodium cyanide solutions, 50 cc of each having been titrated with 0.1 per cent sodium sulphide solution until a brownish color was just produced. A deduction of 0.05 cc is made to cover the amount of sodium sulphide which could be added without reacting with the silver present.

Per cent free cyanide (as K Cg)	Silver present mgrms per liter	Na₂ S required mgrms per liter	Equiv. sol. Ag per cent (as Ag₂ S) mgrms per liter
0.50	490	5.3	14.7
0.40	392	4.4	12.2
0.30	294	3.1	8.6
0.20	196	2.0	5.5
0.10	98	1.0	2.8
0.05	49	0.7	1.9

In this table the milligrams per liter may be read as grams per metric ton. It shows that the amount of silver capable of being dissolved as the soluble double alkali cyanide is approximately proportional to the amount of free cyanide present, but even with 0.5 per cent solution the quantity of dissolved silver is less than 0.5 oz. per 2000-lb. ton. Moreover, the introduction, through presence of free alkali or otherwise of soluble sulphide from any mineral or other source into an argentiferous cyanide solution will result in the precipitation of silver already dissolved. The author explains the fact that in practice many ounces per ton of silver existing as sulphide in the ore can be dissolved by the occurrence of secondary reactions, namely, the conversion of the soluble alkaline sulphide first formed into other compounds which do not preclude the further solution of silver. These secondary reactions are the following: (a) $2 Na_2 S + 2 O_2 = Na_2 S_2 O_3 + Na_2 O$; $Na_2 S_2 O_3 + Na_2 O + 2 O_2 = 2 Na_2 SO_4$. (b) $Na_2 S + Na Cy + O = Na Cy S + Na_2 O$. (c) $Na_2 S + Pb O = Pb S + Na_2 O$, $Pb S + Na Cy + O = Na Cy S + Pb O$. All these reactions involve absorption of oxygen, which appears to account for the utility of aeration. It appears from the first equation, mentioned in the beginning of the article, that the silver requires nearly its own weight of sodium cyanide to dissolve it and, therefore, the consumption of cyanide from this source alone would be nearly 1 lb. of sodium cyanide per ton. This fact would render the field for cyanide regeneration processes more promising than it has been in gold cyanide practice.

Laboratory Tests on the Use of Coarse and Fine Lime for Cyaniding.—With a view of ascertaining the relative rapidity with which commercial lime in varying states of division would be dissolved when distributed through a charge of inert sand and subjected to the action of percolating water, Dr. W. J. Sharwood instituted a series of laboratory experiments, the results of which are published in the April, 1908, issue of the journal of the Chemical, Metallurgical and Mining Society of South Africa. The proportions of water, sand and liquid were practically the same as those which prevail in the leaching of tailings at the cyanide plants of the Homestake mine, namely, an addition of about 3.5 lb. of lime per ton of sand, through which solution percolates at the rate of about one ton of solution in five days for each ton of sand. The conclusions from the results obtained by Dr. Sharwood confirm the experience obtained in Homestake practice, namely, that the most desirable condition is to have the lime largely in particles which are neither very coarse nor extremely fine. If much of it is in granules, that is, coarser than a 20 line mesh screen, these grains will remain partly undissolved at the end of the treatment. Previously-slaked lime and particles finer than 100 mesh yield about 95 per cent of their available alkali in five days' leaching, but they yield it at a rate which is not sufficiently uniform. Such highly comminuted lime gives too high an alkalinity to the cyanide solution at the earlier stages of leaching,

and this, with the pyritic ore in question, is detrimental to the solution of the gold, as it has been found that a protective alkali higher than 0.3 lb. per ton of solution gives decidedly low extractions. A further point in favor of granular lime is that the acidity of these tailings is distinctly cumulative, as there are 5 to 10 per cent of sulphide of iron present, a large proportion of which is pyrrhotite. The lime used in the Homestake plant is burned in continuous wood-fired kilns and is afterward crushed through a jaw crusher to about 1½-in. size. Sufficient is weighed out for a two-hours' supply, and this is dumped into the hopper of a Challenge feeder supplying the mortar of a one-stamp mill, having one screen, 11 in. x 14 in., and fed with a small stream of water. This carries the lime to a launder where it mixes with the previously classified tailings on their way to the distributor and leaching tank. A further addition of lime is made during the progress of leaching by spreading 200 lb. over the surface of each charge of 600 tons. However, if the alkalinity of the ealier effluents is unduly high in comparison with the percentage of cyanide, this top lime is omitted.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Vanadium.— F. M. Becket, 893,128, July 14, 1908. Appl. filed June 26, 1907. Assigned to Electro Metallurgical Co.

Vanadium sulphide ores are directly reduced in an electric furnace by means of calcium carbide or a mixture of calcium oxide and carbon. In the former case the reaction is $5 V_x S_y + y Ca C_2 = 5 x V + y Ca S$.

Low-Carbon Ferroalloys.— F. M. Becket, 892,211, June 30, 1908. Appl. filed Jan. 8, 1908. Assigned to Electro Metallurgical Co.

Ferrotungsten and ferrovanadium are made in an electric furnace with iron electrodes which act as a supply of iron for the ferroalloys. The electrodes are cooled to regulate their consumption and the composition of the product.

Electric Furnace.— F. M. Becket, 892,212, June 30, 1908. Appl. filed Jan. 8, 1908. Assigned to Electro Metallurgical Co.

In order to reduce the radiation of heat from an open electric furnace, the operation is carried out in such a way that a solid crust is maintained on the surface of the fused charge. By properly proportioning the cross-section of the depending electrodes to the current employed, they are so heated as to prevent the crust from forming over the portions of the bath immediately adjacent the electrodes. In this way openings in the solid crust are provided which permit the charge to be supplied or stoked, and also provide for the escape of gases. The essential conditions of operation comprise an adjustment between the current density or heat development in the molten bath or slag and the composition or fusibility of the bath.

Low-Carbon Ferroalloys.— F. M. Becket, 891,898, June 30, 1908. Appl. filed Aug. 24, 1905. Assigned to Electro Metallurgical Co.

Low-carbon ferrochromium, etc., is produced by making first an alloy high in silicon and low in carbon and then eliminating the silicon by reacting upon further quantities of ore. The operation in case of ferrochromium is as follows: Chromite containing from 50 to 52 per cent $Cr_2 O_3$ and from 16 to 17 per cent of Fe O is mixed with sand, sufficient carbon to reduce not only the oxides of chromium and iron, but also a part or all of the silicious material, and a flux, such as lime, to form a suitable slag. This mixture is treated in an electric furnace, yielding an alloy containing 51.3 per cent chromium, 17.5 iron, 30 silicon and 1.2 carbon, if equal quantities of chromite, sand and coke have been used. This is the first step of the process. The second step consists in treating this alloy in another electric furnace with a mixture of chromite and a flux, such as lime. The silicon of the first alloy combines with the oxygen of the oxides in the chromite and forms silica, which passes into the

slag. If 6 lb. of chromite are employed for every pound of silicon in the alloy, the resulting alloy contains 70 per cent chromium, 28.9 iron, 1 carbon, and 0.1 silicon.

Calcium Carbide.—H. L. Hartenstein, 889,124, May 26, 1908. Appl. filed Feb. 13, 1907.

Lime is taken from the preheater or calcining furnace, while highly heated, and is mixed with a mixture of anthracite coal and coke or charcoal. The inventor prefers to employ anthracite coal screenings, which are in a more or less fine condition, and to 80 or 90 per cent of which he adds from 10 to 20 per cent of the coke or charcoal, which is also previously ground. By using anthracite coal and coke it is practicable to utilize the cheaper grades of coke, as breeze or refuse, which is higher in ash and impurities than lump coke and contains much more than the anthracite coal. The use of anthracite coal alone would have objectionable features, such as excessive smoke, precluding a fair view of the electrodes when the furnace is opened for examination, and further it has a high resistance and consequently requires a higher voltage. These objections are sufficiently overcome by the addition of the coke or charcoal, but the results may be still further improved by the addition of a small portion (say, from 3 to 20 per cent) of bituminous coal, rich in tarry compounds, say, about 5 per cent. This is also employed in a state of fine subdivision.

Dark Coatings on Metals.—A. Classen, 891,982, June 30, 1908. Appl. filed Sept. 3, 1907.

The object is to produce a uniform metallic deposit of pure black or deep blue color. The process is particularly suited for depositing nickel, but may also be used for other metals. The articles is polished and the polish dulled by dipping into an acid bath or by means of a sand blast. The article is then electroplated with nickel in a solution producing white, shining nickel and containing, besides the ordinary salts, a decoction of licorice root or licorice root itself. The following composition of a bath is stated to give good results: 20 kg nickel sulphate, 4 kg sodium sulphate, 1 kg nickel chloride and 0.5 kg boracic acid are dissolved in 100 liters of water and 5 kg extract of licorice root, or simply the root itself, is added to the solution. After a white, shining deposit is produced in this manner, the voltage is suddenly reduced considerably without removing the article from the bath. The desired dark color is thereby produced.

Plating Apparatus.—G. G. Backus, 889,744, June 2, 1908. Appl. filed Aug. 15, 1907. Assigned to Zucker, Levett & Loeb Co.

Mechanical details of construction of an automatic apparatus for electroplating articles in large quantities and in a continuous operation. A series of drums carrying the articles to be plated is moved along through the electrolytic tank while the drums are simultaneously rotated. A runway is provided for discharging the drums in succession as they arrive at the end of the tank.

Electroplating.—C. Glover, 892,417, July 7. Application filed Oct. 22, 1907.

Details of mechanical construction of a plating apparatus with a carrier adapted to move conveyors through the plating solution; these conveyers may be readily detached at will for the substitution of new articles to be plated.

Purifying Water and Sewage.—A. E. Woolf, 892,486, July 7, 1908. Appl. filed Jan. 11, 1908.

Sea water or an artificial 3-per cent sodium chloride solution is electrolyzed for the production of hypochlorite. This is used for sterilizing the water or sewage, which is simultaneously subjected to filtration. The third claim refers to "the process of treating liquid to effect sterilization, consisting in preliminarily effecting a partial sterilization passing the incompletely sterile liquid through a filter bed, maintained in operative sterile condition through the action of electrolytically produced disinfecting solution passing there through, and adding to the resultant effluent an excess of the disinfecting solution to effect complete sterilization."

Filtration of Atmospheric Nitrogen.—A. J. Petersson, 889,857, June 2, 1908. Appl. filed April 13, 1906.

The reaction chamber contains a central electrode and a ring-shaped or screw-shaped electrode surrounding the latter. The discharge takes place between the two electrodes radially while the air is moved in the direction of the axis. Excitation devices are provided around the reaction chamber for creating within the latter a magnetic field of axial direction. By this arrangement of the electrodes and the magnetic field in relation to each other, "it will be possible to obtain the power, by which the arc is displaced, proportional or approximately proportional to the length of the path that each part of the arc has to run, whereby the various points of the arc will be displaced at the same angular velocity, thus obviating the risk of the arc being disrupted." For creating the arc the inventor uses alternating current; for creating the magnetic field he uses either direct current or alternating current.

Concentrating Nitric Acid.—B. F. Halvorsen, 892,516, July 7, 1908. Appl. filed Feb. 9, 1906.

Electric discharges through air for the purpose of fixation of atmospheric nitrogen yield dilute nitrous gases. They may be absorbed by sulphurous acid, in which case nitroso sulphuric acid is obtained, or they may be directly absorbed by concentrated sulphuric acid in absorption towers. The object of this patent is to obtain concentrated nitric and concentrated sulphuric acid from such nitroso sulphuric acids or nitrosyl sulphuric acid. The nitrous acid or the nitroso sulphuric acid is dissolved in an excess of concentrated sulphuric acid. A small quantity of water is added, together with a suitable oxidizing agent, as MnO_2, $Pb\,O_2$ or chromic acid in such quantities as are necessary for oxidation. The nitric acid obtained is then distilled off in retorts of cast iron and the oxidizing substance is regained by electrolysis. Before the electrolytic process takes place the solution is diluted with water in sufficient quantity necessary for the electrolytic oxidation. The latter may, for example, be effected as follows: $Cr_2\,(SO_4)_3 + 6\,H_2O = 2\,CrO_3 + H_2\,SO_4 + 3\,H_2$. When the oxidizing substance has been recovered, a certain quantity of the sulphuric acid is taken away and the rest of the sulphuric acid, together with the oxidizing substance, is again utilized for the oxidation of another quantity of nitrous acid.

RECENT METALLURGICAL PATENTS.

Extraction of Copper from Oxide Ore.—W. A. Hendryx (889,129, May 26, 1908) patents a method of leaching copper from oxide ores in two steps. The ore, in a suitable state of subdivision, is thoroughly agitated in a solution of sodium chloride, calcium chloride or other saline solution capable of effecting at solution of the metal at a temperature which may vary from 120° Fahr. to the boiling point of the solution. By this treatment a substantial proportion of the metal contained in the ore, in the case of oxidized copper ores usually about 50 per cent, is brought into solution. The inventor then adds to the ore pulp, while still heated and without separating the saline solution therefrom, sulphuric acid, equivalent to the weight of metal remaining undissolved in the ore. The pulp is then subjected to heat and agitation for a further period of time until practically complete solution is effected. The metal-bearing solution is separated by discharging the pulp upon a sand filter and precipitating the copper by means of scrap iron in a rotary precipitating apparatus. The inventor has found in practice that a solution tank 17 ft. in diameter is capable of treating approximately 40 tons of ore at a charge and that 10 such charges may be treated in a day, the total capacity of each tank being, therefore, about 400 tons of ore in 24 hours. The essential economy of the method lies in the use of a relatively cheap saline solvent, such as sodium chloride or calcium chloride, to extract from the ore such proportion of the metal as can be rapidly dissolved by this solvent, acids being employed only to

complete the solution, and added only in quantity equivalent to the metal remaining in the ore after the saline treatment.

Amalgam for Mirrors.—J. Laval (892,435, July 7) patents an amalgam for coating glass in the production of mirrors. This amalgam is stated to be advantageous in its use when compared with chemical processes of silvering glass, in that it does not turn yellow or peel off if subjected to the action of the sun or heat, and will not tarnish or streak from dampness. The amalgam consists of 5 parts antimony, 20 lead, 20 tin and 15 mercury.

Fused Quartz.—In Lond. *Elec. Eng'ing,* of June 11, a process of Ludwig, Bolle & Co., for the electric fusing, refining and molding of quartz articles is described, being protected by British patent 5764 of 1907. "Silica is fused by heating it electrically in a horizontal or vertical carbon tube, which forms one electrode, in an electric furnace. The tube is surrounded by powdered carbon or other resistance material, and this is contained in a wide carbon tube, which forms a second electrode, the whole apparatus being cased in refractory bricks. One end of the inner carbon tube is closed by means of a movable carbon plug, the other by a plunger which can be lowered into the melted material. The silica may be compressed into the form of a solid block, or it can be pressed against the walls of a carbon tube so as to form a hollow cylinder, depending upon the shape of the plunger. The plunger may also be made hollow, and then steam or compressed air can be forced through it into the carbon tube. At the end of the operation the plug at the bottom of the tube may be removed, then the plunger can be employed to eject the silica."

Extraction of Gold.—To extract gold, platinum, silver from refractory ores, J. B. Alzugaray (892,110, June 30) treats the coarsely powdered ore by means of hydrogen fluoride produced by the decomposition of any fluorine compound by sulphuric acid. For this purpose the ore is mixed with fluorspar and a sulphate or sulphuric acid. The hydrogen fluoride which is evolved reacts on the ore and disintegrates it with the evolution of silicon fluoride, which can be recovered by passing the gaseous compound through a condenser in contact with water.

Galvanized Steel Poles.

An interesting novel departure in electric transmission line practice in the use of galvanized steel poles as manufactured by Milliken Brothers of New York City. The design of these poles has been completely standardized by this firm and special arrangements have been made in their bridge and structural shops for the manufacture of these poles.

The rolled steel shapes are carefully cut, punched and bent by special, automatic tools which insure the accuracy of each piece made. These special tools enable them not only to turn out a large quantity of material, but insure each piece being an exact duplicate, a matter that is very important in connection with work to be shipped in pieces. After the shop work is completely finished on the steel parts, they are taken to the galvanizing department, where they are galvanized by the hot process (except the bolts and nuts). This department is entirely new and specially designed and directed to do this particular kind of work.

The hot zinc bath which is used for the work is by far the largest bath of its kind ever constructed and is capable of taking in pieces somewhat over 30 ft. in length at one time, thus insuring a uniform deposit. The old-fashioned method was to use a very much shorter bath and dip the long members in one end at a time. This, of necessity, made a joint in the galvanizing, which is believed to be exceedingly detrimental. The bolts and nuts are galvanized by the electric process on account of the threads.

Standard specifications for galvanized steel poles, together with interesting notes on tests, methods of shipment, etc., may be found in a pamphlet recently issued by Milliken Brothers and entitled The Milliken Patent Galvanized Steel Poles.

The Hancock Jig in a Triple Separation.

A recovery of 98 per cent of a waste material in making three useful products is the remarkable record of the Hancock Jig installed at the plant of the New Jersey Zinc Co. (of Pa.) at Hazard, Pa.

The Hazard plant is furnished with ore from the mines at Franklin Furnace, N. J. These ores are complicated in composition, containing several zinc ores, such as Franklinite, Willemite, Zincite, etc., aggregating about 26 per cent zinc oxide when the ore is concentrated.

The process of treatment consists of two parts, the oxide furnace treatment and the blast furnace treatment. In the former the concentrated ore is mixed with fine anthracite coal and charged into small furnaces, where the zinc is driven off as oxide—the zinc white of the metallic paint manufacturer.

The residue is a clinker containing the iron 38 per cent, manganese 11 per cent, and some unburned coal and zinc ore. This residue is passed over a screen and the coarse clinker treated in a blast furnace, producing spiegel iron. Since the starting of the plant the fine material from the screen has been waste. The fine coal and zinc was found to play havoc with the blast furnaces, eating out the linings and choking the throats with zinc oxide.

After years of operation the pile of waste became a mountain, and the management began to figure on its disposal.

After some experiments with Hartz Jigs and sizing processes, and with magnetic separation, the Hancock Jig was installed and proved a great success. It makes a triple separation, *i. e.,* zinc ore containing 16 to 18 per cent zinc oxide, for re-treatment in the oxide furnaces, iron manganese clinker, running 40 per cent iron and 14 per cent manganese for treatment in the blast furnaces, and unburned coal, running 65 per cent carbon, used in the oxide furnace charge. The only waste is 2 per cent ash, which is carried with the overflow water into a settling tank. The water is settled and pumped back into the jig, about 20 per cent being lost in each circulation.

The tonnage handled by the jig at this place is 15 tons per hour, or 360 tons per 24 hours, but it is capable of handling, if required, between 400 and 500 tons of material in 24 hours, which the jig handles easily. The feed is the regular run of fines from the furnaces heated after a cooling period of six hours.

This machine is the regular 25-ft. size Hancock Jig manufactured by the Allis-Chalmers Company, Milwaukee, Wis.

Notes.

Sifting and Mixing Machinery.—The Abbie Engineering Company, St. Paul Building, New York City, have opened a department, in charge of Mr. J. M. Charles, for the sale of silk and wire bolting cloth for use in pulverizing and fine grinding of chemicals, clays, colors and other materials.

Dr. Heraeus, the distinguished German chemist and metallurgist, has received from the Franklin Institute, of Philadelphia, the John Scott Legacy Premium and Medal for his improvements of the Heraeus-Le Chatelier pyrometer and the accuracy and interchangeability of the thermocouple which he has produced and which is known as the Heraeus element. Dr. Heraeus is represented in this country by his brother-in-law, Mr. Charles Engelhardt, Hudson Terminal Buildings, 30 Church Street, New York City.

The Moore Filter Company report that they have closed a contract with the Compania Beneficiadora de Metales, "La Union," S. A., for the erection of a type A Moore slime plant,

having a daily capacity of 150 tons dry slime, at the La Union mine of Pachuca, Mexico, of which Sr. Don Francisco Narvaez is manager. This type A plant was selected after careful investigation by Sr. Narvaez and on the recommendation of Mr. George Moore in preference to the type B, or stationary type, particularly.

The Laclede-Christy Clay Products Company, of St. Louis, Mo., announce the acquisition of the business, property and good will of the Jamieson-French Fire Clay Co., Lake Junction, St. Louis Co., Mo. Mr. Henry K. Lackland, formerly secretary and general manager of the latter company, will be associated with the Laclede-Christy Clay Products Co. in the capacity of manager of their high-grade clay department.

Messrs. Brown & Williams, patent attorneys, of 1550 Monadnock Building, Chicago, announce that Mr. Adolph A. Thomas has recently become associated as an assistant in their office. Mr. Thomas has for four years been an assistant examiner in the electrical division of the United States Patent Office. His time will be chiefly devoted to interference cases and patent applications involving chemical, electrochemical and alternating-current technique.

Messrs. Colne & Co., 11 Broadway, New York City, formerly Powell & Colne, contractors for the erection of Tropenas steel casting plants for over 10 years, have just completed an equipment at the Mare Island Navy Yard, California, which is now in successful operation, thus making 33 converters installed by them.

Digest of U. S. Patents.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

Electric Furnaces.—(*Continued.*)

No. 504,282, Aug. 29, 1893, Solomon Shaw, Milwaukee, Wis. Assigned to E. P. Allis Co.

Arc type. Shaft furnace for melting iron. The receiving chamber has a downwardly-converging bosh, connected by a narrow throat with a wide crucible below. Four horizontal radial carbon electrodes are arranged in passages opening into the throat. These electrodes are automatically fed by electromagnetic mechanism. Side flues may lead through the walls from the crucible to the upper chamber, supplying hot gases to preheat the iron. The crucible has a drop-bottom.

No. 504,308, Aug. 29, 1893, Solomon Shaw, Milwaukee, Wis. Assignor to E. P. Allis Co.

Arc type. Shaft furnace for melting iron and iron ore. The upper charge-receiving chamber and its crucible are connected by a narrow throat. The horizontal radial electrodes enter the lower end of the upper chamber. The crucible has two tapholes at different heights.

No. 512,602, Jan. 9, 1894, Charles L. Coffin, Detroit, Mich.

Arc type. Forge for heating or working metal, comprising a refractory bed of calcined limestone, dolomite or marble and an upper block or blocks having openings receiving the metal and carbon electrodes. The electrodes are electromagnetically fed. An electromagnet beneath the bed deflects th arc. The bed contains a spiral of pipe by which hot air or gas may be fed through a nozzle into the heating zone.

No. 513,270, Jan. 23, 1894, A. F. W. Kreinsen, Mamburg, Germany.

Feeds the lower end of a rod electrode of metal to be melted against the lower end of a carbon rod electrode, the two electrodes converging downwards, or may feed the metal rod against the edge of a revolving carbon-disk electrode. The melted metal drops into a plumbago crucible heated to a temperature of 1600° to 2000° C. by a platinum resistance wire imbedded in its walls, or by a thin external sheath of platinum

acting as a resistor. The electrodes are inclosed by a hood covering the crucible.

No. 513,602, Jan. 30, 1894, Elihu Thomson, Lynn, Mass.

Resistance type. The resistor may be a carbon rod or plate or set of parallel rods or slabs; may be spiral or sinuous or crucible-shaped, or a loop, or a tube, or it may consist of a number of blocks or rings pressed together endwise. A spring may be used to force the terminals against the resistor. The resistor may be imbedded in powdered charcoal, in which a graphite crucible may be imbedded. The inclosure may be of carbon bricks set in carbon cement and may be traversed by tubes. The electric circuit may contain a fuse, which may be under tension, to prevent overheating. Its rupture may ring a bell. The conductors may be cooled by water circulation.

No. 530,019, Nov. 27, 1894, Charles L. Coffin, Detroit, Mich.

Arc type. Chamber of soapstone, slate, lava or iron, lined with slabs of carbon, lime or magnesia.

No. 530,479, Dec. 4, 1894, Geo. A. Goodson, Minneapolis, Minn.

Resistance type. Maintains temperature of molten type metal flowing through a tube to the mold by making the tube a resistor.

NEW BOOKS

Synthetic Inorganic Chemistry. By Arthur A. Blanchard. A laboratory course illustrating the methods and principles involved in the preparation of typical inorganic substances, with study questions and supplementary experiments; arranged for first-year college students. 97 pages. Bound in cloth. Price, $1 net. New York: John Wiley & Sons.

Laboratory Manual of Qualitative Analysis. By Wilhelm Segerblom. 148 pages. Price, $1.25. New York: Longmans, Green & Co.

An Introductory Course of Quantitative Chemical Analysis; with Explanatory Notes and Stoichiometrical Problems. By Paul H. Talbot. Fifth edition, revised and rewritten. 183 pages. Bound in cloth. Price, $1.50 net. New York: Macmillan Co.

Determination of Radicals in Carbon Compounds. By Hans Meyer. 232 pages. Bound in cloth. Price, $1.25 net. New York: John Wiley & Sons.

Lead and Zinc in the United States. By Walter Renton Ingalls. Bound in cloth. Price, $4 net. New York: Hill Publishing Co.

American Iron and Steel Association Directory to the Iron and Steel Works of the United States. Seventeenth edition, corrected to March 1, 1908. 516 pages. Bound in cloth. Price, $12.

Electricity in Mining. By Sydney Ferris Walker. 505 pages; illustrated. Bound in cloth. Price, $3.50. New York: D. Van Nostrand Co.

Principles of Direct-Current Electrical Engineering. By Jas. R. Barr. 59 pages; 294 illustrations. Bound in cloth. Price, $3.25 net. New York: Macmillan Co.

Development and Electrical Distribution of Water Power. By Lamar Lyndon. 323 pages; figures, 80. Bound in cloth. Price, $3 net. New York: John Wiley & Sons.

The Theory, Design and Construction of Induction Coils. By H. Armagnat. Translated and edited by Otis Allen Keyon. 222 pages. Bound in cloth. Price, $2 net. New York: McGraw Publishing Co.

The Mathematical Theory of Electricity and Magnetism. By Ja. Hopwood Jeans. 544 pages; diagrams. Bound in cloth. Price, $4.50. New York: G. P. Putnam's Sons.

"The Electrician," handy copper wire tables and formulæ; compiled by P. D. Brown. 34 pages. Bound in cloth. Price, $1 net. New York: D. Van Nostrand Co.

An Introduction to Electricity: being a translation of the second edition of Einführung in die Elektrizitätslehre, with cor-

rections and additions by the author. By Bruno Kolbe. Translated by Jos. Skellon. 442 pages. Bound in cloth. Price, $3 net.

THE GLASS-SAND INDUSTRY OF NEW JERSEY. By Barnard H. Kummel and R. B. Gage. 173 pages. Trenton, N. J.

MATHEMATICS OF MACHINE DESIGN, WITH SPECIAL REFERENCE TO SHAFTING AND EFFICIENCY OF HOISTING MACHINERY. By C. F. Blake. 35 pages; diagrams. Price, 25 cents. New York: Industrial Press.

BLANKING DIES. 40 pages, illustrations, diagrams, 80 (Machinery's reference ser.). Paper binding. Price, 25 cents. New York: Industrial Press.

THE PRINCIPLES OF MECHANICS: FOR STUDENTS OF PHYSICS AND ENGINEERING. By H. Crew. 305 pages. Bound in cloth. Price, $1.50. New York: Longmans, Green & Co.

LOGARITHMIC AND OTHER TABLES FOR SCHOOLS. By Frank Castle. 36 pages. 20 cents net. New York: Macmillan Co.

A VEST-POCKET HANDBOOK OF MATHEMATICS FOR ENGINEERS. By L. A. Waterbury. 97 pages; illustrated. Price, $1 net. New York: John Wiley & Sons.

BOOK REVIEWS.

NOTES ON HYDRO-ELECTRIC DEVELOPMENTS. By Preston Player. 73 pages, 3 illustrations. Price, $1 net. New York: McGraw Publishing Company.

This little book is essentially one for the financier, treating the subject always from the side of the investor with just enough engineering to make clear the points taken. It will, however, be very useful to engineers who have reports to make on the development of water power. It carries the development through from the investigation of the site to the building up of the market for the energy.

The list of chapters will give an idea of the character of the book: Preliminary Determinations; Methods of Procedure; Engineering Examination; Extent of the Market for Energy; Cost of Energy Manufacture; Central Station Economics; Sale of Electrical Energy; Primary and Secondary Power; Capital Costs.

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THE THEORY, DESIGN AND CONSTRUCTION OF INDUCTION COILS. By H. Armagnat. Translated and edited by Otis Allen Kenyon. 212 pages, 109 illustrations. Price, $2 net. New York: McGraw Publishing Co.

The field of application of the induction coil has greatly extended in the last few years and has created a demand for a theoretical treatment of the design which more nearly expresses the truth than has heretofore been the case.

Up to the present nearly all data which have been published on induction coils applied to special coils, and so little of the data required to render the results of universal application were given that they were of little use to designers.

To those who are interested in the theory, design or operation of induction coils (and there should be quite a number among electrochemists) we recommend this book, and can safely say it is the best of its kind that we have seen.

The abbreviated list of contents given below will give a good idea of the field covered by the book: History; Theory of Mechanical Interrupters; Theory of Electrolytic Interrupters; Secondary Current; Power and Efficiency; Construction of Induction Coils; Construction of Interrupters; Special Induction Apparatus; Uses of Induction Coils; Bibliography (1832 to 1908).

Mr. Kenyon has again carried out his task as translator and editor in a manner which deserves the highest recommendation.

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ELECTRICAL CONTRACTING: SHOP SYSTEM, ESTIMATING, WIRING CONSTRUCTION, METHODS, AND HINTS ON GETTING BUSINESS. By Louis J. Auerbacher. 161 pages, 225 illustrations. Price, $2 net. New York: McGraw Publishing Co.

This is a book for contractors and wiremen, especially useful to the small contractor who is new in the work and needs to establish an efficient shop system and build up his business. The book gives a complete shop system; tells how to design and install wiring for arc and incandescent lamps, alternating- and direct-current motors, alarms, telephones, gas-lighting systems, etc., and gives many hints which will enable the contractor to make good profit off a given job.

The abreviated list of contents is as follows: Shop System for Electrical Contractors; Estimating on Contract Work; Wiring Systems; Exposed Circuit Wiring; Wiring with Wooden Moldings; Wiring with Flexible Conduit and Armored Cable; Wiring with Iron Conduit; Residence Wiring; Wiring for Direct-Current and Alternating-Current Motors; Installation and Operation of Direct-Current Generators and Switchboards; Electric Signals and Telephone Systems; Special Devices.

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UNIVERSAL CALCULATING CHART. By Thomas R. Taltavall. Chart, 24-ply cardboard (7 in. x 9 in.). Booklet of instructions. 34 pages, 15 illustrations. Price complete, $1 net. New York: McGraw Publishing Co.

This device consists of a rectangular co-ordinate scale similar to ordinary cross-section paper, fitted with a transparent celluload arm which is pivoted in the lower left-hand corner and carries a linear scale equal to the one on the chart. By placing the arm at any angle, the arm forms one side of the triangle, the other two sides of which may be read off on the co-ordinate scale. The upper horizontal and right vertical edges of the chart are provided with an angular scale, permitting the angle at which the arm is set to be read in degrees and minutes.

With this device in sine, cosine, tangent, cotangent, secant and cosecant can be read directly to three places. Trignometric problems involving these functions can be solved directly without the use of the function. Multiplication and division are accomplished by utilizing the properties of similar triangles, the arm being set at the intersection of 10 with one of the numbers to be multiplied; then, at the intersection of the second number with the arm will be found the product of the two numbers.

It is believed, however, that this device will find its greatest field of usefulness in the solution of alternating-current problems, where vectors in quadrature are often encountered. By laying the resistance and reactance off as abscissa and alternates, respectively, and placing the arm at the intersection of the arm, the impedance, angular-phase displacement and power factor can be read off directly, and if it is desired to change from the impedance to the admittance triangle, this can be done with one setting of the arm, and the conductance and the susceptance determined.

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THERMOCHEMISTRY. By Julius Thomsen. Translated from the Danish by Katharine A. Burke, D. Sc. 510 pages, illustrated. Price $2.50. (Textbooks of Physical Chemistry of Wm. Ramsay.) New York: Longmans, Green & Co.

Sir Wm. Ramsay, as editor of the Textbooks of Physical Chemistry, deserves the thanks of all students of physical chemistry for having made Thomsen's classical work on thermochemistry available to English readers.

The fourth edition of Thomsen's Thermochemische Untersuchungen appeared in 1886. The immense fundamental value of this work has always been fully recognized. It is a human document, summing up the results of a lifework, full of endeavor. All results are directly the outcome of Thomsen's own experimental work in thermochemistry. All have been found by his own methods, with the same apparatus and under the same external conditions. All are directly comparable.

The translation by Miss Burke is excellent, but the editing seems to have been slightly overdone. An attempt has been made to modernize certain statements. But hyper-modern readers will hardly be satisfied. And, on the other hand, Thomsen's work is a classic and should be treated as such. It is out of place to try and modernize a classic.